ENERGY AUDIT AND MANAGEMENT

VI Semester (IARE-R16)

Prepared

By

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UNIT – I

GENERAL ASPECTS

Why the Need for Energy Audit

- The three top operating expenses are energy (both electrical and thermal), labour and materials.
- Energy would emerge as a top ranker for cost reduction
- primary objective of Energy Audit is to determine ways to reduce energy consumption per unit of product output or to lower operating costs
- Energy Audit provides a " bench-mark" (Reference point) for managing energy in the organization

NEED OF ENERGY AUDIT

- Minimizing energy waste
- Optimizing efficiency with suitable technology
- Using most appropriate energy resource
- Buying energy at most economical price
- Minimize operational cost
- Minimize cost of repair and re construction
- Increase the quality of environment to increase productivity

Need for Energy Audit

- Energy Audit will help to understand more about the ways energy and fuel are used in any industry, and help in identifying the areas where waste can occur and where scope for improvement exists.
- The Energy Audit would give a positive orientation to the energy cost reduction, preventive maintenance and quality control programmes which are vital for production and utility activities.
- Audit programme will help to keep focus on variations which occur in the energy costs, availability and reliability of supply of energy, decide on appropriate energy mix, identify energy conservation technologies, retrofit for energy conservation equipment etc.

ENERGY AUDIT OBJECTIVES

The objectives of an energy analysis or audit are to identify and develop modifications that will reduce the energy use and/or cost of operating a building. The results should be presented in a format that will provide the information needed by an owner/operator to decide if any or all of the recommended modifications should be implemented.

Energy Audit

- "Energy audit is a systematic study or survey to identify how energy is being used in a building or plant, and identifies energy savings opportunities."

- **Definition** : "The verification, monitoring and analysis of use of energy including submission of technical report containing recommendations for improving energy efficiency with cost benefit analysis and an action plan to reduce energy consumption".

The Objectives of Energy Management

1. To achieve and maintain optimum energy procurement and utilisation, throughout the organization

2. To minimise energy costs / waste without affecting production & quality

3. To minimise environmental effects.

Principles of Energy management

i) Control the cost of energy service provided and not the BTU
ii) Manage energy function as a product cost and not as a general expenses
iii) Manage only major energy functions
iv) Concentrate energy management program on installing contracts and achieving results

Principles of Energy Conservation and energy Audit:

- Energy conservation means reduction in energy consumption but without making any sacrifice quality and quantity of production.
- In other words, **for the same energy consumption, higher production.**
- It does not prevent you to use of energy by fixing some limits quantitavely within the agreement but insists for use efficiently thus decreasing the cost of production to some extent by way of reduction in the energy bill.
- **Thus energy saved is the money earned which would be used in other productive means.**
- It is therefore imperative that electricity which is in shortage, be utilized efficiently and the areas of where the energy is wastefully used are to be identified and corrective measures are searched for adoption. This could be done by **"Energy Audit".**
- **Energy audit is a technical survey of a plant in which the machine wise, section wise department wise pattern of energy consumption is studied and attempts to balance the total energy input correlating with production.**

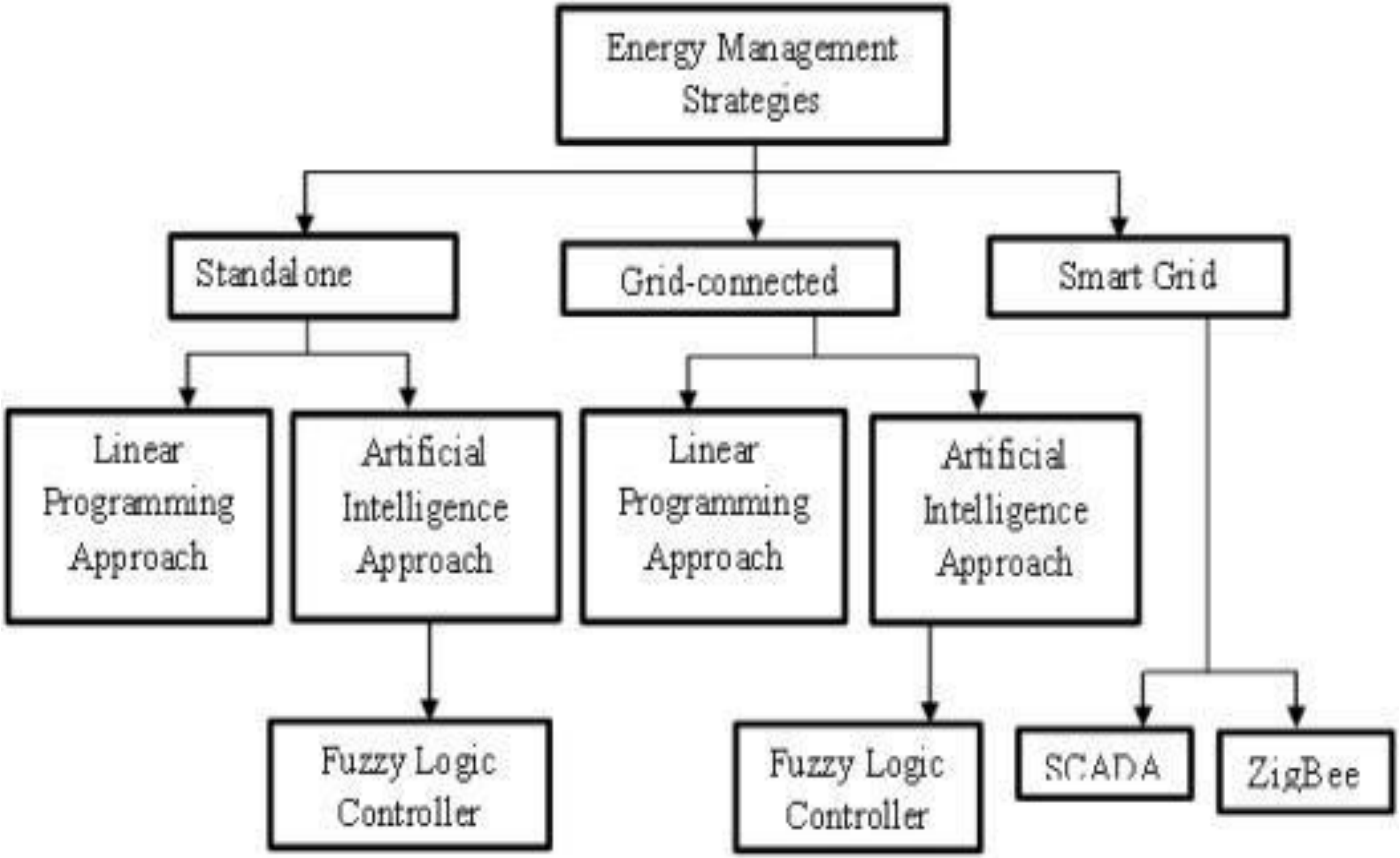
Principles

Can be summed as,

- **Eliminating** unnecessary energy use
- **Improving efficiency** of energy use
- **Buying energy** at lower cost
- **Adjusting operations** to allow purchasing energy at lower prices

Energy Manager Skills

- Have sufficient technical knowledge either to understand the implemented technology or to be able to get trained in the technology
- Able to establish the organization structure
- Plan energy survey
- Identify educational needs
- Development strategy of energy management
- Able to understand economic evaluations like payback, life cycle cost.
- Have ability to communicated effectively and motivated the team.


Energy Management Strategies
Standalone
Grid-connected
Smart Grid
Linear Programming Approach
Artificial Intelligence Approach
Linear Programming Approach
Artificial Intelligence Approach
Fuzzy Logic Controller
Fuzzy Logic Controller
SCADA
ZigBee

Types of Energy Audits

1. Preliminary Energy Audit
2. Targeted Energy Audit
3. Detailed Energy Audit

Types of energy audits

- Preliminary energy audit
- Detailed energy audit
- Targeted audit on energy systems
- Walk through audit
- Audits for investment in energy conservation technologies

Preliminary Audit

Preliminary energy audit is a relatively quick exercise to:

- Establish energy consumption in the organization
- Estimate the scope for saving
- Identify the most likely (and the easiest areas for attention
- Identify immediate (especially no-/low-cost) improvements/ savings
- Set a 'reference point'
- Identify areas for more detailed study/measurement
- Preliminary energy audit uses existing, or easily obtained data

Targeted Energy Audits

Targeted energy audits are mostly based upon the outcome of the preliminary audit results.

They provide data and detailed analysis on specified target projects.

As an example, an organization may target its lighting system or boiler system or compressed air system with a view to bring about energy savings.

Targeted audits therefore involve detailed surveys of the target subjects/areas with analysis of the energy flows and costs associated with those targets.

Detailed Energy Audit

Detailed Energy Audit evaluates all systems and equipment which consume energy and the audit comprises a detailed study on energy savings and costs.

Detailed Energy Audit is carried out in 3 phases

- The Pre-audit Phase
- The Audit Phase
- The Post-Audit Phase

The Ten Steps for Detailed Audit

Step No	PLAN OF ACTION	PURPOSE / RESULTS
	<u>Phase I –Pre Audit Phase</u>	
Step 1	• Plan and organise • Walk through Audit • Informal Interview with Energy Manager, Production / Plant Manager	• Resource planning, Establish/organize a Energy audit team • Organize Instruments & time frame • Macro Data collection (suitable to type of industry.) • Familiarization of process/plant activities • First hand observation & Assessment of current level operation and practices
Step 2	• Conduct of brief meeting / awareness programme with all divisional heads and persons concerned (2-3 hrs.)	• Building up cooperation • Issue questionnaire for each department • Orientation, awareness creation

Step 3	Phase II –Audit Phase • Primary data gathering, Process Flow Diagram, & Energy Utility Diagram	• Historic data analysis, Baseline data collection • Prepare process flow charts • All service utilities system diagram (Example: Single line power distribution diagram, water, compressed air & steam distribution. • Design, operating data and schedule of operation • Annual Energy Bill and energy consumption pattern (Refer manual, log sheet, name plate, interview)
Step 4	• Conduct survey and monitoring	• Measurements : Motor survey, Insulation, and Lighting survey with portable instruments for collection of more and accurate data. Confirm and compare operating data with design data.

Step 5	• Conduct of detailed trials /experiments for selected energy guzzlers	• Trials/Experiments: - 24 hours power monitoring (MD, PF, kWh etc.). - Load variations trends in pumps, fan compressors etc. - Boiler/Efficiency trials for (4 – 8 hours) - Furnace Efficiency trials Equipments Performance experiments etc
Step6	• Analysis of energy use	• Energy and Material balance & energy loss/waste analysis
Step 7	• Identification and development of Energy Conservation (ENCON) opportunities	• Identification & Consolidation ENCON measures • Conceive, develop, and refine ideas • Review the previous ideas suggested by unit personal • Review the previous ideas suggested by energy audit if any • Use brainstorming and value analysis techniques • Contact vendors for new/efficient technology
Step 8	• Cost benefit analysis	• Assess technical feasibility, economic viability and prioritization of ENCON options for implementation • Select the most promising projects • Prioritise by low, medium, long term measures
Step9	• Reporting & Presentation to the Top Management	Documentation, Report Presentation to the top Management.

Step10	Phase III –Post Audit phase • Implementation and Follow-up	Assist and Implement ENCON recommendation measures and Monitor the performance ▪ Action plan, Schedule for implementation ▪ Follow-up and periodic review

Understanding energy costs

An industrial energy bill summary

ENERGY BILL EXAMPLE			
Type of energy	Original units	Unit Cost	Monthly Bill (Rs)
Electricity	5,00,000 kWh	Rs.4.00/kWh	20,00,000
Fuel oil	200,kL	Rs.11,000 KL	22,00,000
Coal	1000 tons	Rs.2,200/ton	22,00,000
Total			64,00,000

Conversion to common unit of energy

Electricity (1 kWh) = 860 kcal/kWh (0.0036 GJ)
Heavy fuel oil (calorific value, GCV) =10.000 kcal/litre (0.0411 GJ/litre)
Coal (calorific value, GCV) =4000 kcal/kg (28 GJ/ton)

Energy Costs in Indian Scenario ?

Common Fuels

- Fuel oil,• Low Sulphur Heavy Stock (LSHS),• Light Diesel Oil (LDO),• Liquefied Petroleum Gas (LPG) • Coal,• Lignite,• Wood

Fuels Cost Inputs & Factors

- Price at source, transport charge, type of transport,
- Quality of fuel
- Contaminations, Moisture, Energy content (GCV)

Power Costs

In India Electricity costs vary substantially not only from State to State, but also from city to city and also within consumer
to consumer – though power does the same work everywhere.

Reason:

•Tariff Structure

BENCHMARKING

- It can be a useful tool for understanding energy consumption patterns in the industrial sector and also to take requisite measures for improving energy efficiency.

- Factors involved

1. Scale of operation
2. Vintage of technology
3. Raw material specification and quality
4. Product specification and quality

BENCHMARKING FOR ENERGY PERFORMANCE

- Internal benchmarking
  - Historical and trend analysis

- External benchmarking
  - Across familiar industries

BENCHMARKING ENERGY PERFORMANCE

- Quantification of fixed and variable energy consumption trends
- Comparison of industry energy performance w.r.t various production levels
- identification of best practices
- Scope and margin available for energy consumption and cost reduction
- Basis for monitoring and target setting exercises

Matching Energy Usage to Requirement

- The mismatch between equipment capacity and user requirement often leads to inefficiencies due to part load operations, wastages etc. It is thus essential that proper energy matching studies are carried out & actions implemented.

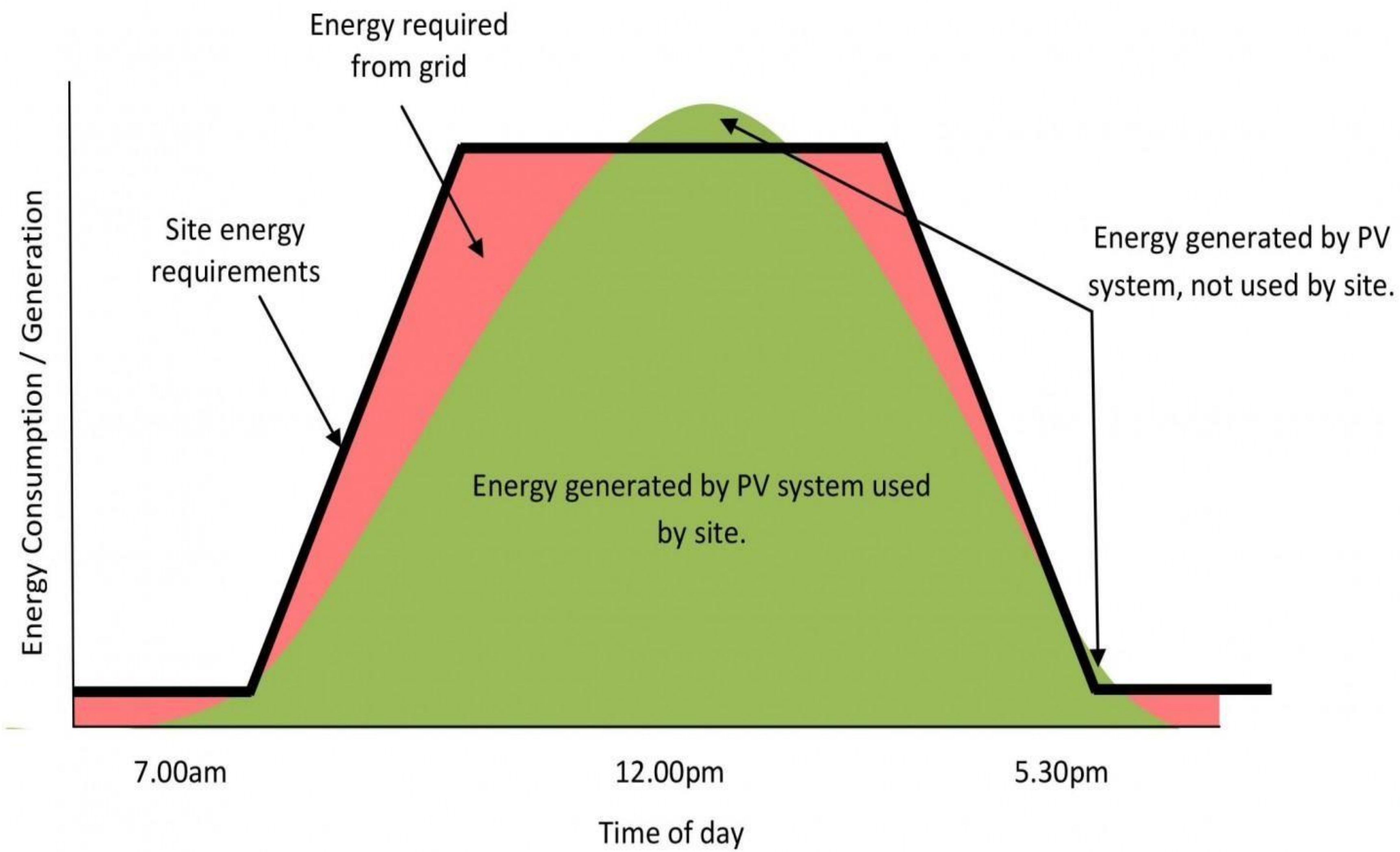
Examples :

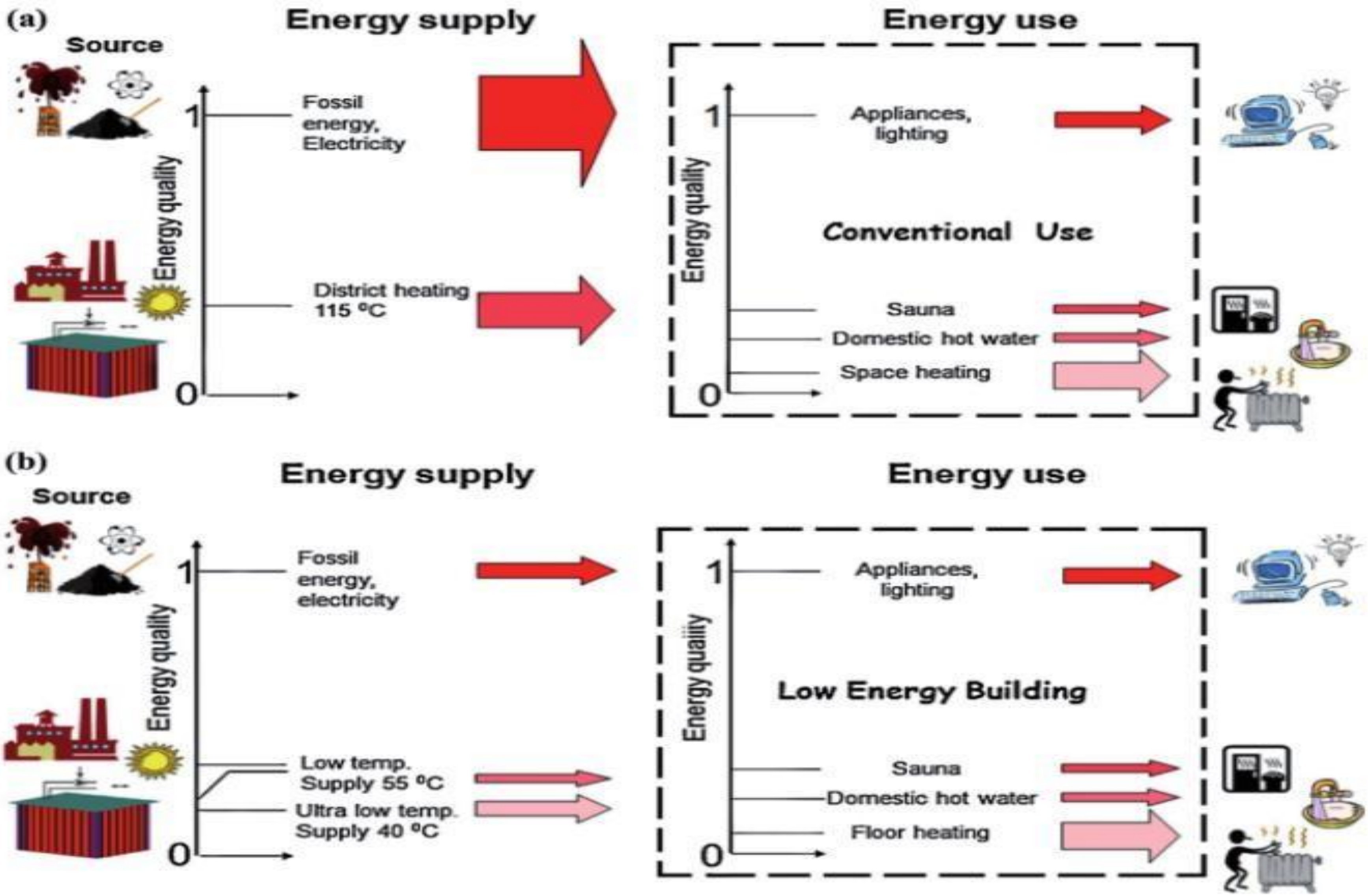
Eliminate throttling

Eliminate damper operations

Fan resizing for better efficiency.

Moderation of chilled water temperature for process chilling needs


Energy required
from grid
Site energy
requirements
Energy generated by PV
system, not used by site.
Energy generated by PV system used
by site.
Energy Consumption / Generation
7.00am
12.00pm
5.30pm
Time of day


(a)
Energy supply
Source
Energy quality
1
0
Fossil energy, Electricity
District heating 115 ºC
Energy use
Energy quality
1
0
Appliances, lighting
Conventional Use
Sauna
Domestic hot water
Space heating
(b)
Energy supply
Source
Energy quality
1
0
Fossil energy, electricity
Low temp. Supply 55 ºC
Ultra low temp. Supply 40 ºC
Energy use
Energy quality
1
0
Appliances, lighting
Low Energy Building
Sauna
Domestic hot water
Floor heating

Maximizing System Efficiencies - Some Measures

- Replace pumps, fans, air compressors, refrigeration compressors, boilers, furnaces, heaters and other energy conservation equipment, wherever significant energy efficiency margins exist
- Eliminate steam leakages by trap improvements
- Maximize condensate recovery
- Adopt combustion controls for maximizing combustion efficiency

Optimising Energy Input Requirement

- **In order to ensure that the energy given to the system is being put to optimal use, site specific measures and checks should be carried out regularly.**
- EXAMPLES:
- Shuffling of compressors to match needs.
- Periodic review of insulation thickness
- Identify potential for heat exchanger networking and process integration.

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Fuel and Energy Substitution – key steps towards conservation

<u>Fuel substitution</u>

- Replacement of coal by coconut shells, rice husk etc
- Replacement of LDO by LSHS

<u>Energy substitution</u>

- Replacement of electric heaters by steam heaters
- Replacement of steam based hot water by solar systems

The theory of energy substitution

- Energy input involves work that transforms matter and includes fuels based on natural resources
- Energy substitution starts with the production function x = x (K, L, F, E)
- The firm or industry is assumed to produce the profit maximizing output x* hiring the optimal inputs of capital K, labor L, fertilizer F, and energy E that minimize cost of production

UNIT – II

PROCEDURES AND TECHNIQUES, EVALUATION OF SAVING OPPORTUNITIES AND ENERGY AUDIT REPORTING

Data and Information Analysis

- Plant level information can be derived from financial accounting systems-utilities cost centre
- Plant department level information can be found in comparative energy consumption data for a group of similar facilities, service entrance meter readings etc.
- System level (for example, boiler plant) performance data can be determined from sub metering data
- Equipment level information can be obtained from nameplate data, run-time and schedule information, sub-metered data on specific energy consuming equipment

TABLE 8.2 FUEL CONVERSION DATA

Energy source	Supply unit	Conversion Factor to Kcal
Electricity	kWh	860
HSD	kg	10,500
Furnace Oil	kg	10,200
LPG	kg	12,000

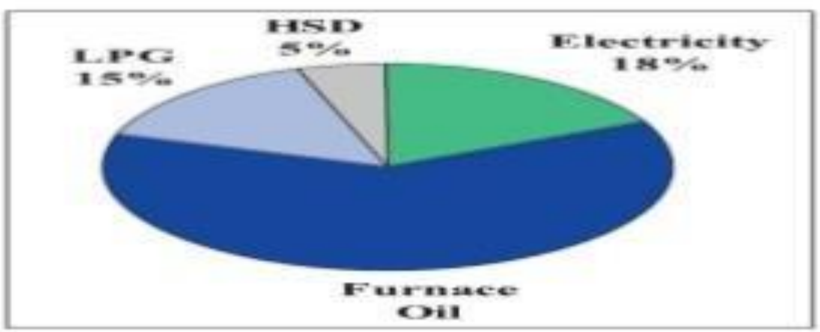


TABLE 8.1 ANNUAL ENERGY COST SHEET

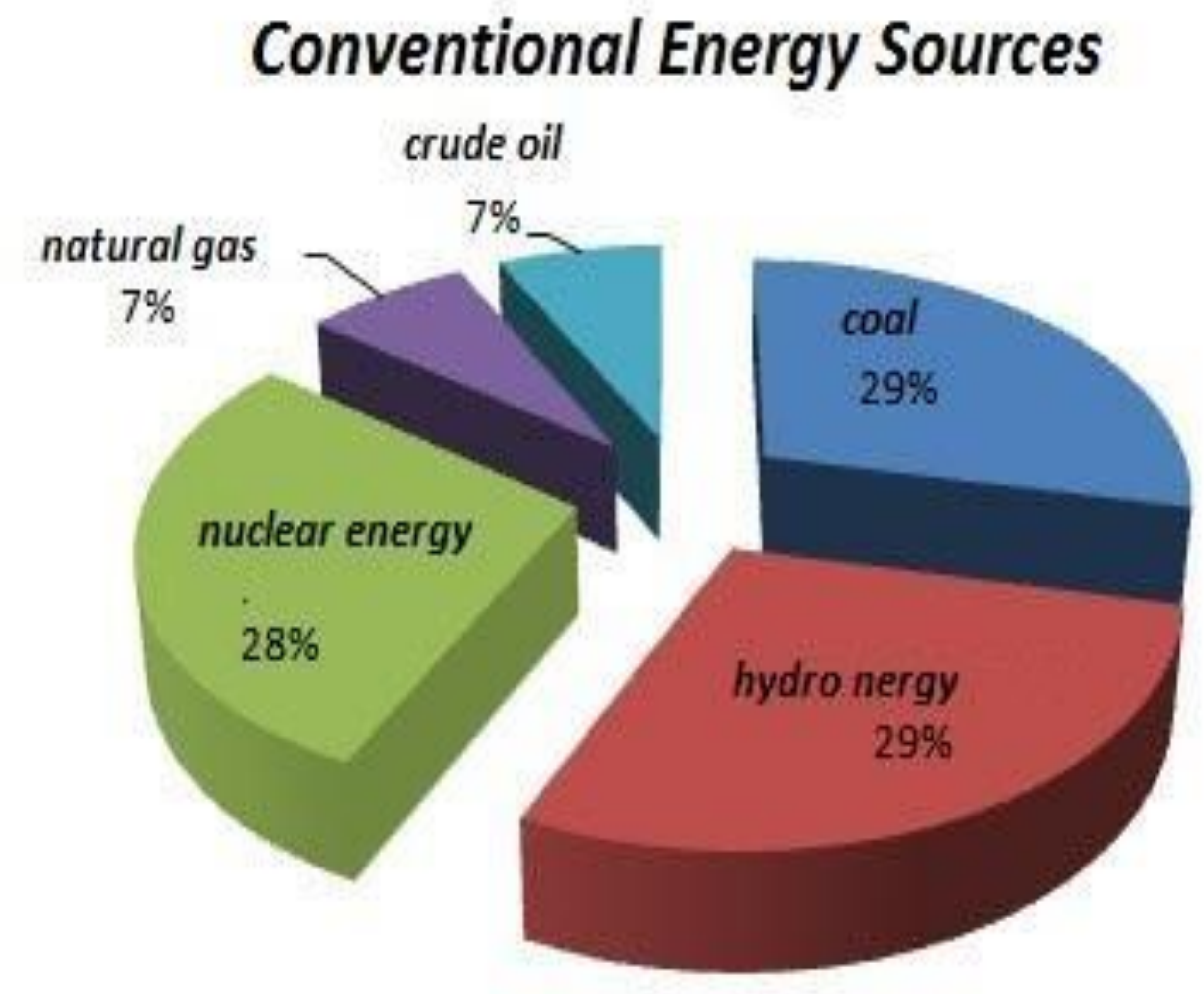
	Thermal Energy Bill				Electricity Bill				Total Energy Bill
Month	Fuel 1	Fuel 2	Fuel 3	Total Rs. Lakh	Day kWh	Night kWh	Maximum Demand	Total Rs. Lakh	Rs.Lakh
1									
2									
3									
4									
b-Total									
%									

1.Top Management Commitment and Support

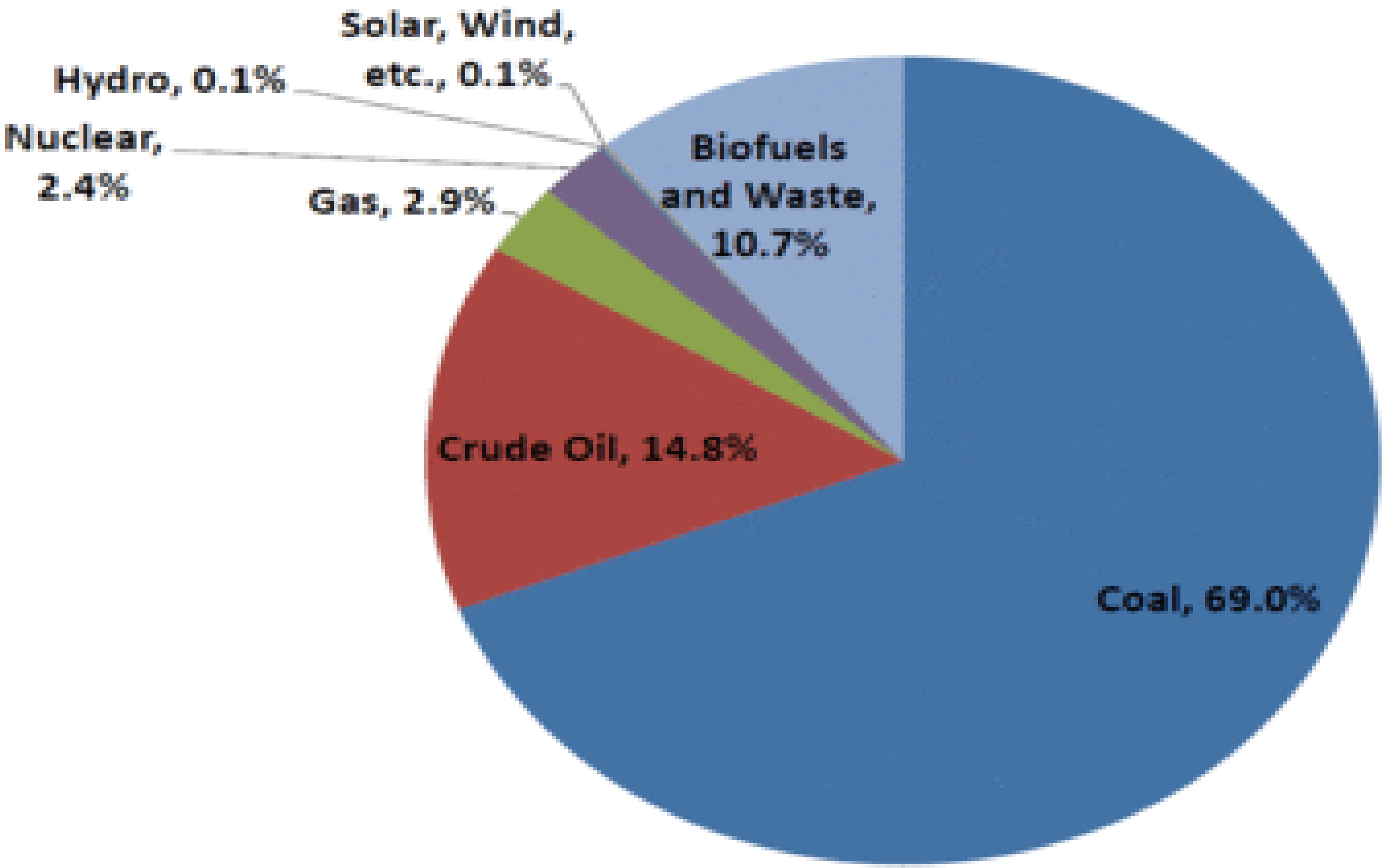
❑ Responsibilities and Duties of Energy Manager

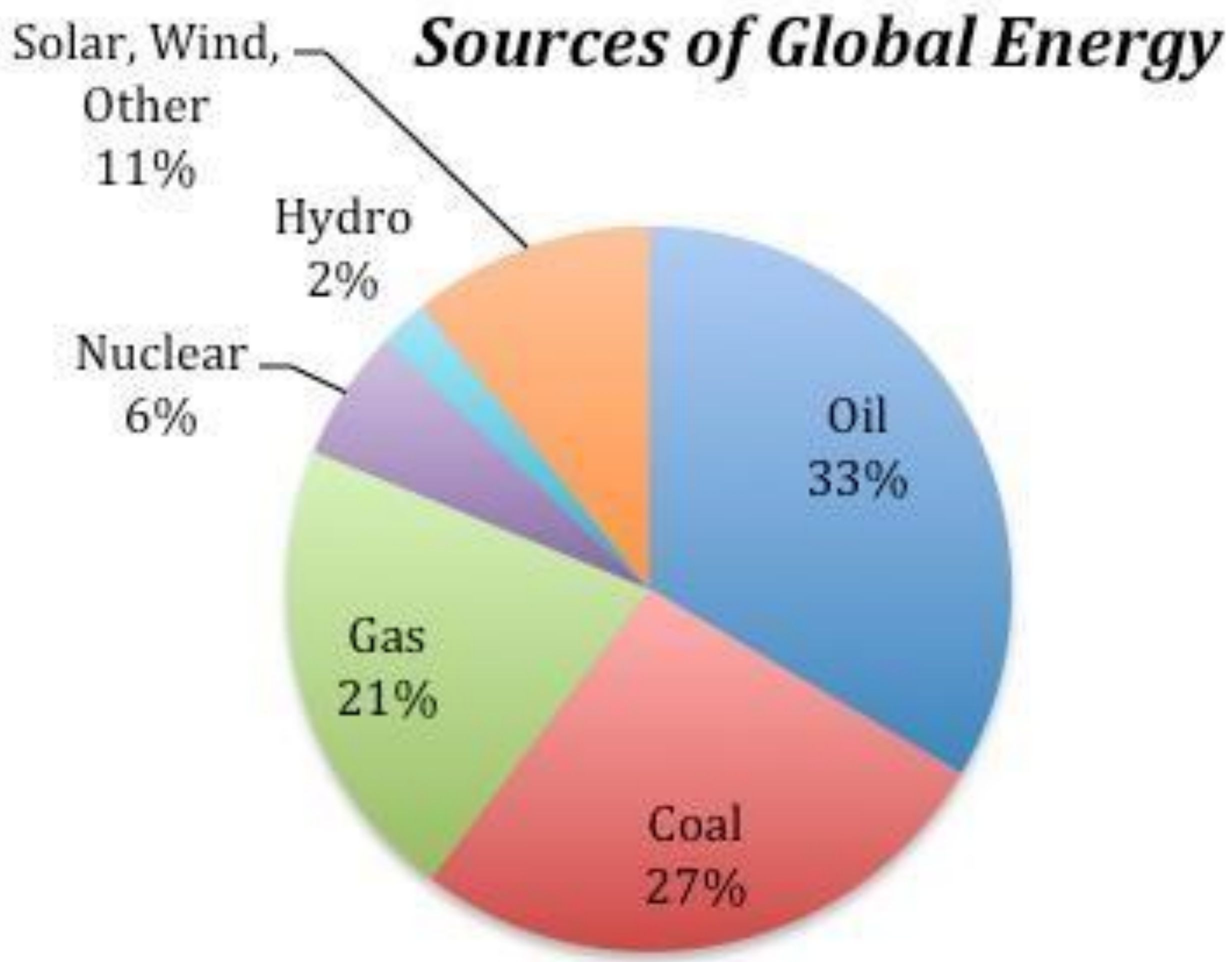
- **Initiate activities** to improve monitoring and process control to reduce energy costs.
- **Analyze equipment performance with respect to energy efficiency**
- **Ensure proper functioning and calibration of instrumentation** required to assess level of energy consumption directly or indirectly.
- **Prepare information material and conduct internal workshops** about the topic for other staff.

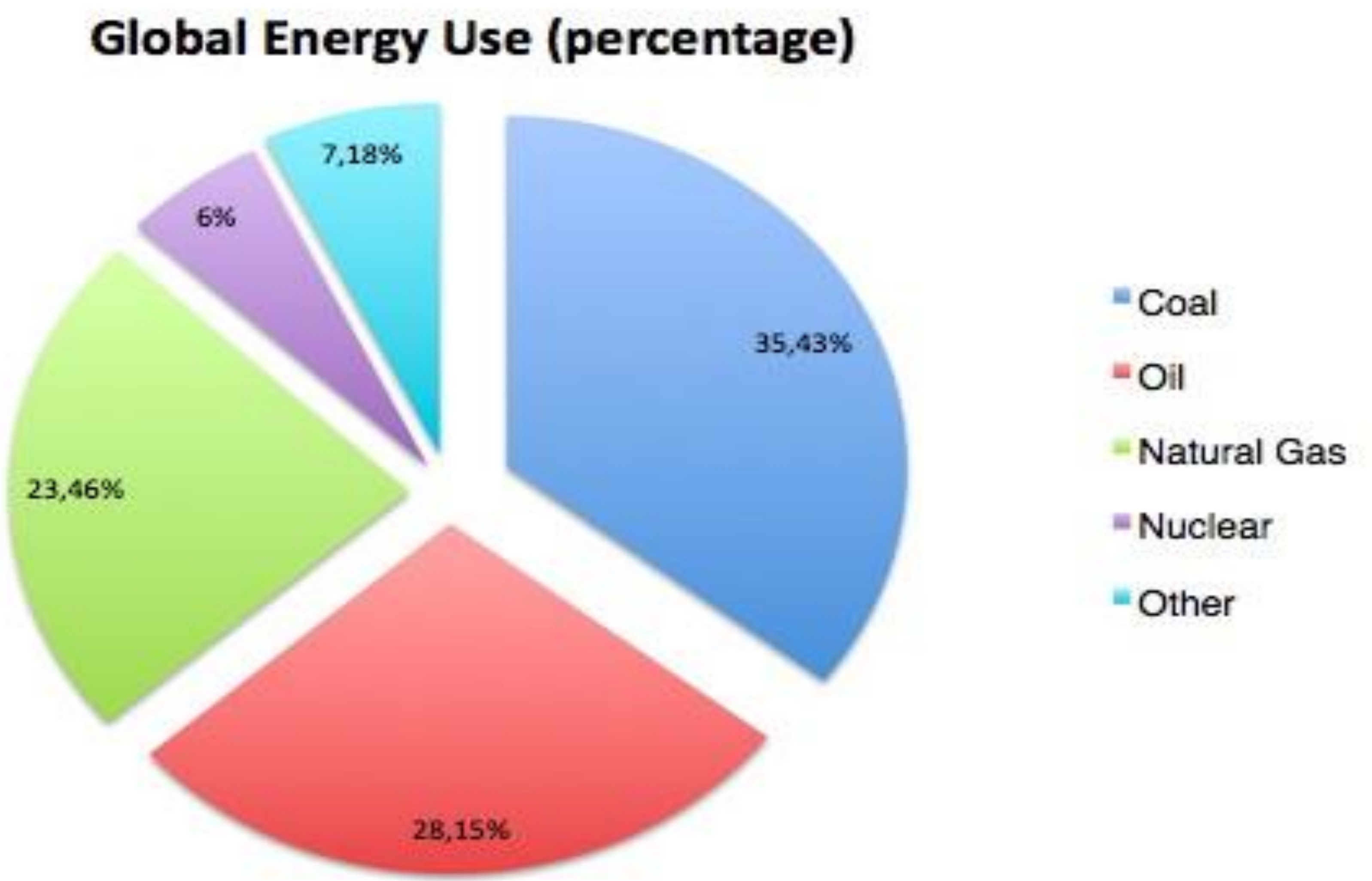
- **Responsibilities and Duties of Energy Manager are highlighted below:**
- Establish an energy conservation cell & prepare an annual activity plan
- Develop and manage training programme for energy efficiency at operating levels
- Develop integrated system of energy efficiency and environmental improvement
- Initiate activities to improve monitoring and process control to reduce energy costs
- Co-ordinate implementation of energy audit/efficiency improvement projects through external agencies
- Establish / participate in information exchange with other energy managers of the same sector through association


Conventional Energy Sources
crude oil
7%
natural gas
7%
coal
29%
nuclear energy
28%
hydro nergy
29%

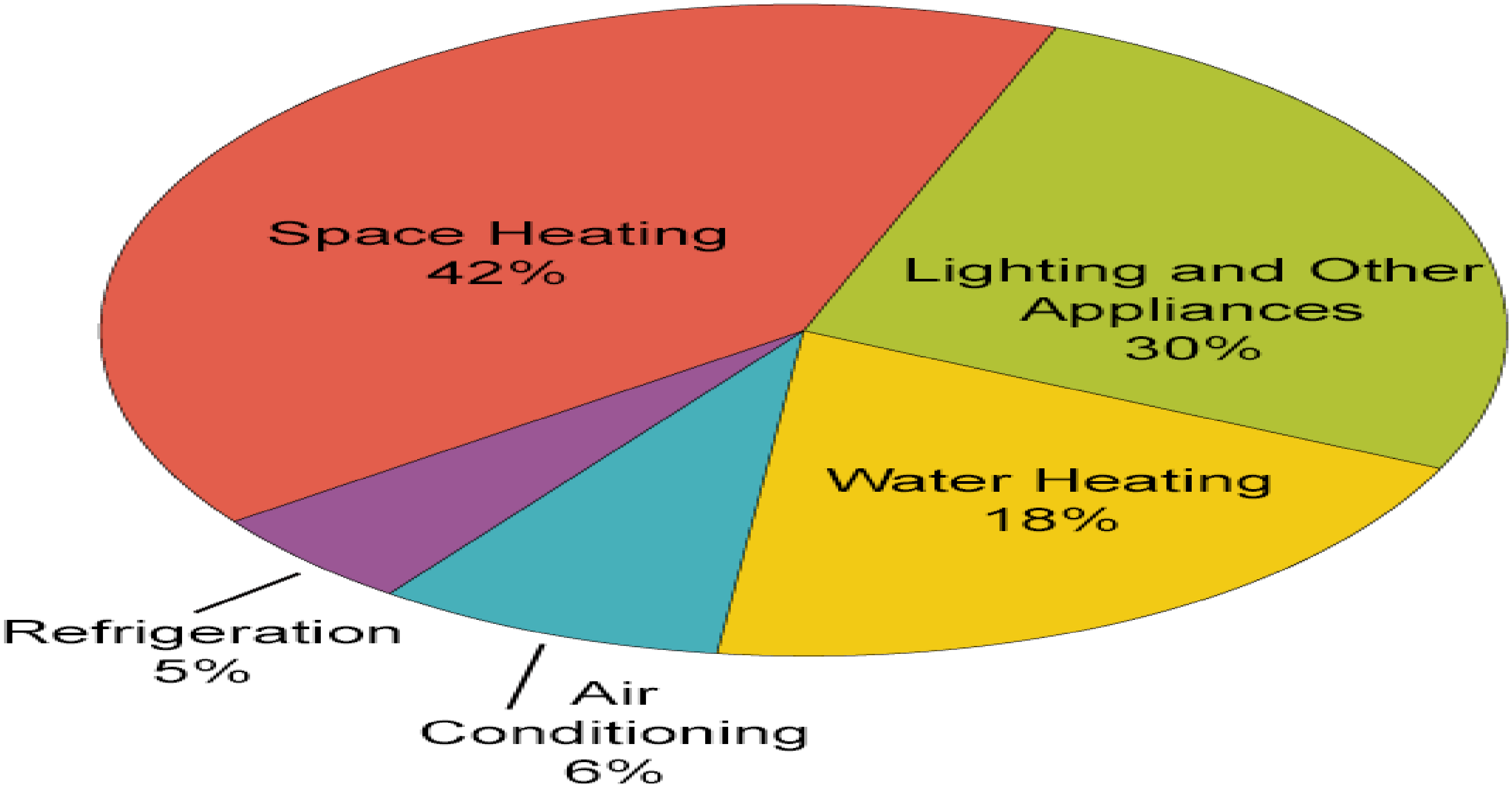
Total Primary Energy Supply in South Africa 2012 [% TPES]




Sources of Global Energy
Solar, Wind, Other 11%
Hydro 2%
Nuclear 6%
Oil 33%
Gas 21%
Coal 27%


Global Energy Use (percentage)
7,18%
6%
35,43%
23,46%
28,15%
Coal
Oil
Natural Gas
Nuclear
Other

How Energy Is Used in Homes (2009)*



* 2009 is the most recent year for which data are available.

Source: U.S. Energy Information Administration, *Residential Energy Consumption Survey (RECS) 2009*.

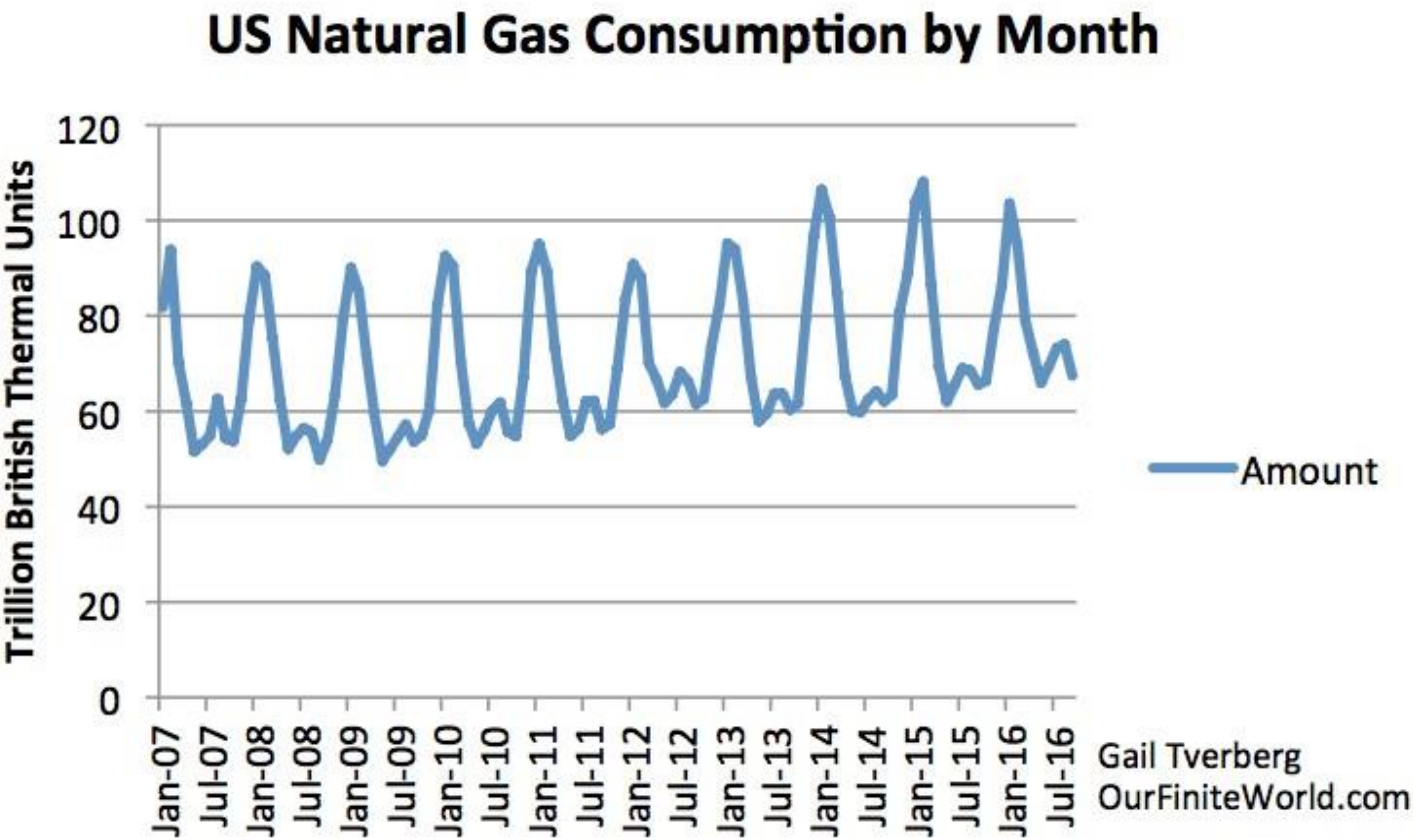
Some Basic Energy Facts

- Energy has a role in everything we do and is *essential* to all life.
- Energy is a *conserved* quantity – it can neither be created nor destroyed.
- Energy may be *converted from one form to another*.
- Energy may be *converted to work,* or *work converted to energy*.
- Fossil fuels provide 90% of the energy we currently use.
- Hundreds of millions of years were needed for fossil fuels to be created on earth.
- The term *energy consumption* refers to the degradation of energy resources to less useful forms

Some Core Facts ...*scoping the problem*

- Electrical energy use currently 330TWH pa , peak power 60GW
- Domestic gas use + road transport fuel = current electricity use
- Electrical energy demand by 2050 expected to double @ least at the end of fossil = 700TWh **with 10%** conservation Source: DECC
- With other uses it could treble e.g: fuel synthesis, de-salination
- IPCC Expects 3 times by 2100
- We will need, and can have, **much more cheap** electricity
- Politicians legislate **less and much more expensive**
- Doubling or Tripling prices with "alternatives" is avoidable stupidity

..........................planning to fail?


US Natural Gas Consumption by Month
Trillion British Thermal Units
120
100
80
60
40
20
0
Jan-07
Jul-07
Jan-08
Jul-08
Jan-09
Jul-09
Jan-10
Jul-10
Jan-11
Jul-11
Jan-12
Jul-12
Jan-13
Jul-13
Jan-14
Jul-14
Jan-15
Jul-15
Jan-16
Jul-16
Amount
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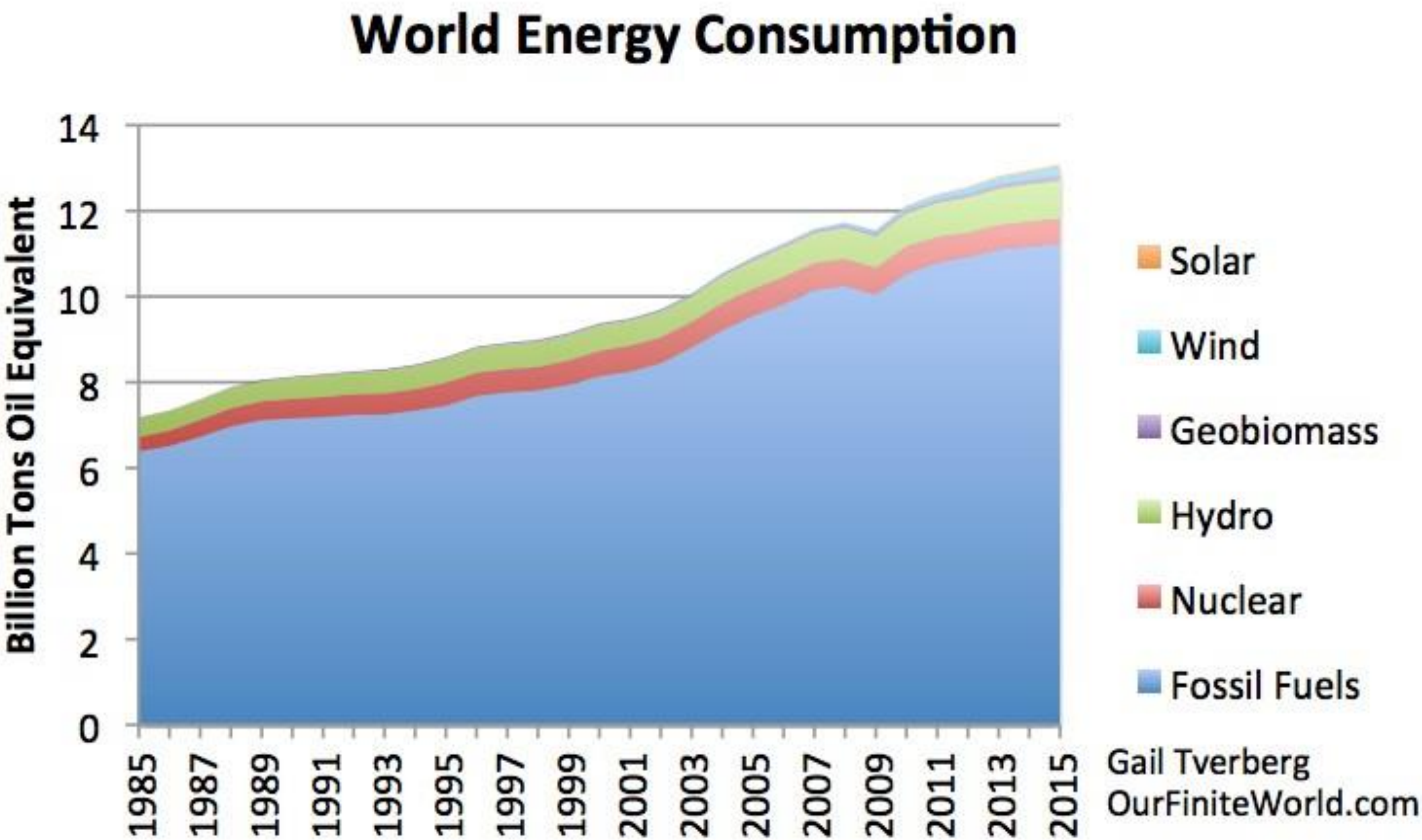
World Energy Consumption
Billion Tons Oil Equivalent
14
12
10
8
6
4
2
0
1985
1987
1989
1991
1993
1995
1997
1999
2001
2003
2005
2007
2009
2011
2013
2015
Solar
Wind
Geobiomass
Hydro
Nuclear
Fossil Fuels
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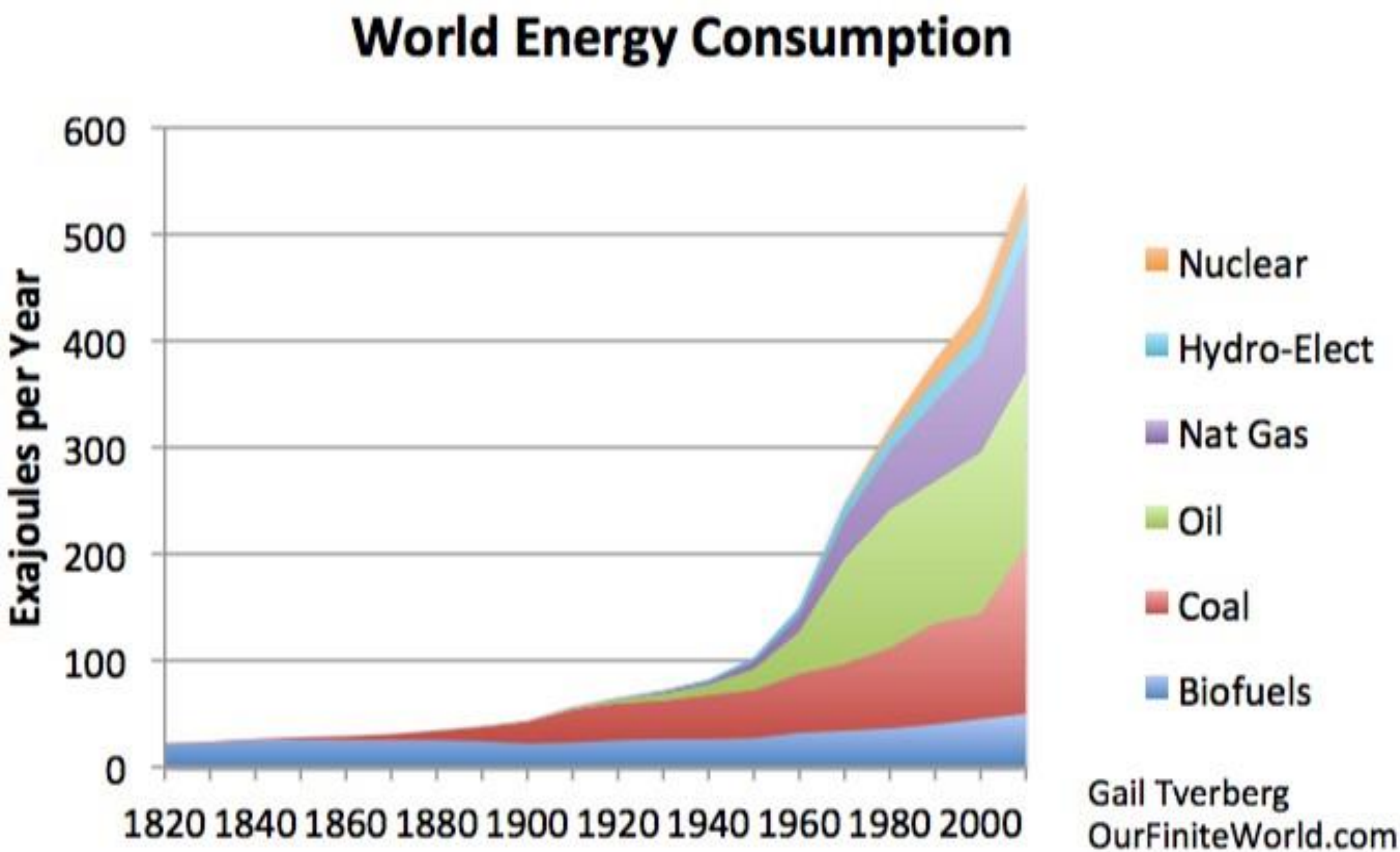
World Energy Consumption
Exajoules per Year
600
500
400
300
200
100
0
1820
1840
1860
1880
1900
1920
1940
1960
1980
2000
Nuclear
Hydro-Elect
Nat Gas
Oil
Coal
Biofuels
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DATA COLLECTION

Specifications and design details contd...

Particulars	
Input kW of the pump	
Speed of the pump	
Year of commissioning	
Motor kW	
Motor make	
Motor voltage	
Rated current of motor	
Motor frame	
Motor rpm	
Rated motor efficiency	
Minimum recirculation required	
Type of flow control system installed	

DATA TABLE

Sr. No.	Description	UOM	Present Pump	Proposed Pump
1	Name			
2	Head	Mtrs.	6.70	
3	Discharge	m3/S	0.013	
4	Input Power motor	KW	3.89	
4	Power consumption daily	kWh	11.67	
5	Efficiency	%	92	
6	Specific Power Consumption	kWh/m3		
7	Running Hrs/day	Hrs.	3	
8	Running Hrs./ Annum	Hrs.	330	
9	Power consumption/Annum	kWh	1283.70	
10	Unit Rate	Rs	8.00	
11	Total expenditure/Annum	Rs.	10269.60	
13	Estimated Saving	**Rs.**	4519.00	
14	Cost of proposed VFD	Rs.		
15	Simple Pay Back Period (year)		**2.27**	

EFFICIENCY AND PERFORMANCE EVALUATION OF THE PUMPS

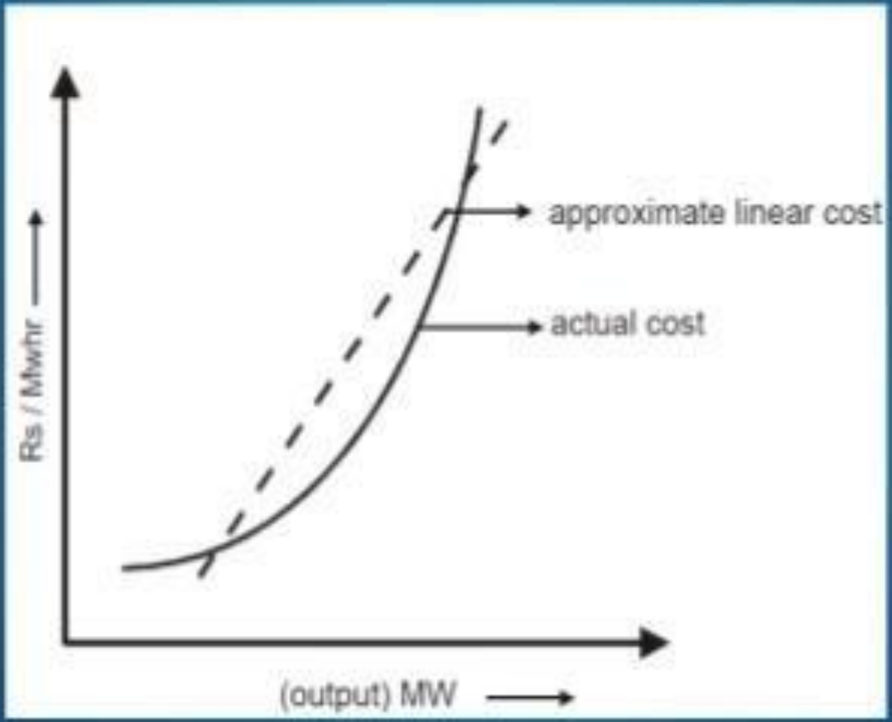
Performance parameters for water pumps contd..

Particulars	Unit	Design/ PG test value	Actual	Remarks
Input kW to the pump			–	
Input kW of the motor		–		
Hydraulic kW				
Combined efficiency				
Motor efficiency (refer to motor performance curve)				
Pump efficiency				
Type of flow control mechanism				
Discharge throttle valve position % open				
Flow control frequency and duration if any				
% loading of pump on flow				
% Loading of pump on head				
% Loading of motor				

The audit team should collect the following baseline data:

- Technology, processes used and equipment details
- Capacity utilisation
- Amount & type of input materials used
- Water consumption
- Fuel Consumption
- Electrical energy consumption
- Steam consumption
- Other inputs such as compressed air, cooling water etc
- Quantity & type of wastes generated
- Percentage rejection / reprocessing
- Efficiencies / yield

INCREMENTAL COST CURVE



1.Incremental Reasoning

The two basic concepts in the incremental analysis are : *incremental cost* and *incremental revenue*.

• **Incremental cost** may be defined as the change in total cost as a result of change in the level of output, investment, etc

•**Incremental Revenue** is change in total revenue resulting from change in level of output , price etc.

Use of Incremental Reasoning

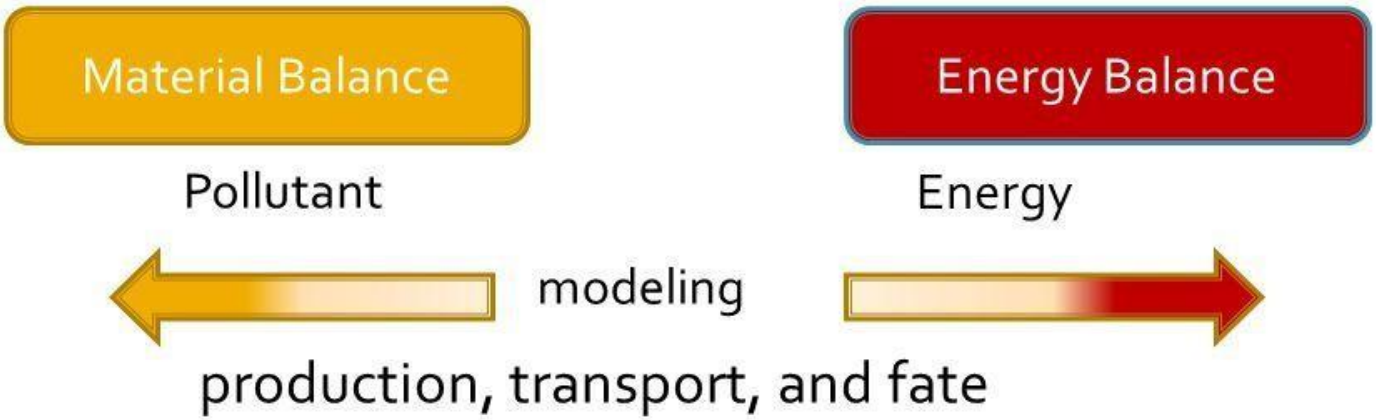
While taking a decision, a manager always determines the worthwhile ness of a decision on the basis of criterion that the incremental revenue should exceed incremental cost.

INCREMENTAL COSTS AND SUNK COSTS

- **Incremental Cost:** IC are closely related to the concept of marginal cost but with a relatively wider connotation. While marginal cost refers to the cost of the marginal unit (generally 1 unit) of output, incremental cost refers to the total additional cost associated with the decisions to expand the output or to add a new variety of product, etc.

- **Sunk Costs:** SC are those which are made once and for all and cannot we altered, increased or decreased, by varying the rate of output, nor can they be recorded.

Materials and Energy Balances



Energy balances in energy audits

The energy balance in EAs differs from current thermodinamic energy balances because some unknowns are obtained by measurements.

Unknowns obtained from measurements have an error of measurement

Oftenly we do also need to assume the values of certain parameters and then to check the balances.

Method: Combination of Life Cycle Inventory (LCI) and GIS

From the LCI:

- List of energy inputs and outputs, biomass and energy conversion models and coefficients

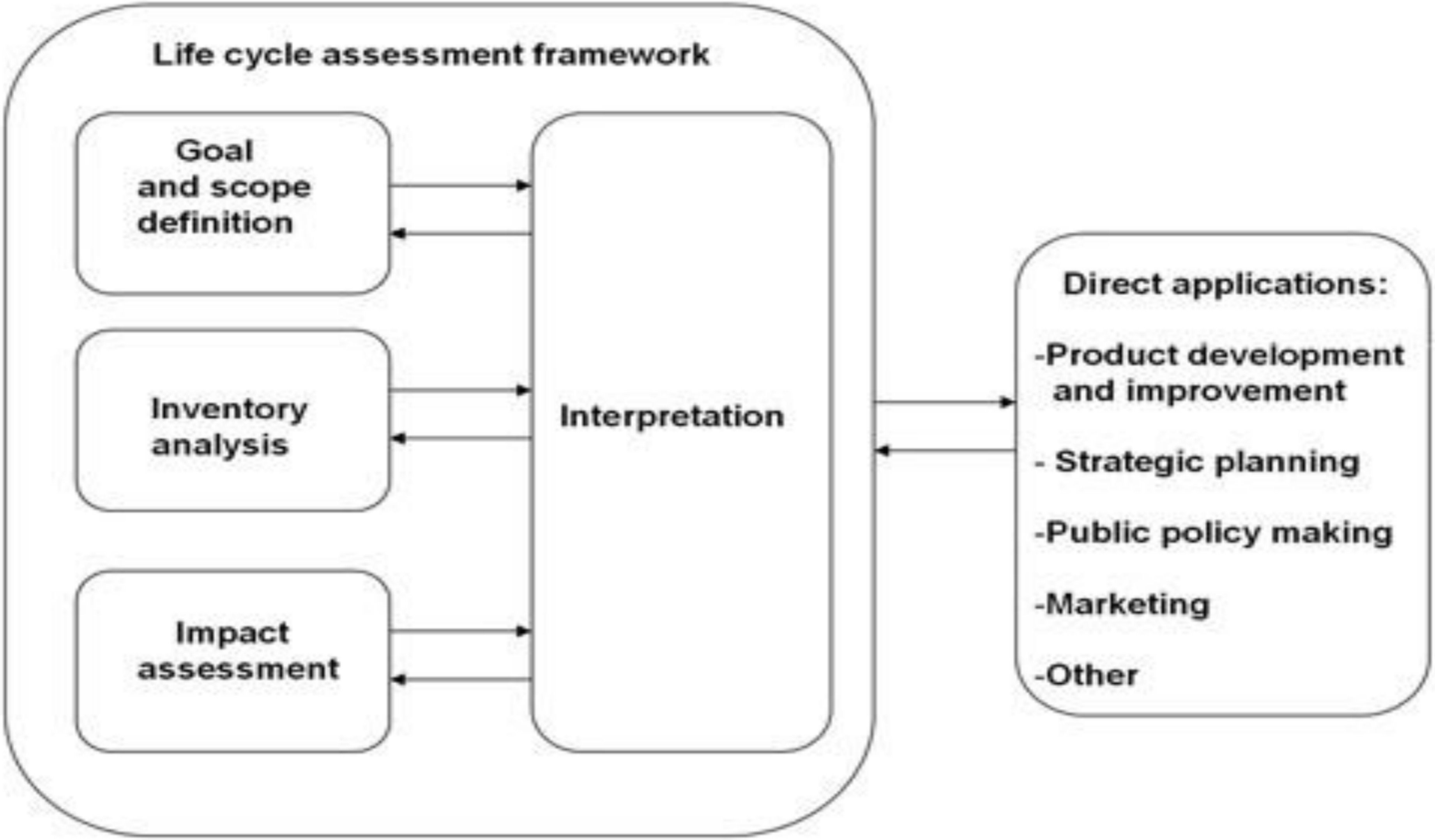
- Estimation of Potential Biomass and Biomass Potentially available for Bioenergy Production

- Estimation of Energy Input and Output of the different bioenergy production options

- Estimation of NEG and EROEI of the different bioenergy production options

From the GIS:

- Estimation of area under natural grassland using GIS coverages (LGN 6 Land cover map)


Life cycle assessment framework
Goal and scope definition
Inventory analysis
Impact assessment
Interpretation
Direct applications:
-Product development and improvement
- Strategic planning
-Public policy making
-Marketing
-Other

$$\begin{pmatrix}\text{Rate of}\\ \text{heat conduction}\\ \text{at } x, y, z\end{pmatrix} - \begin{pmatrix}\text{Rate of}\\ \text{heat conduction}\\ \text{at } x + dx, y + dy, z + dz\end{pmatrix} +$$

$$\begin{pmatrix}\text{Rate of}\\ \text{heat generation}\\ \text{inside the element}\end{pmatrix} = \begin{pmatrix}\text{Rate of change of}\\ \text{energy content}\\ \text{of the element}\end{pmatrix}$$

Estimates of Heat Transfer Coefficients:

Type of Heat Transfer, Fluids	W / m²°C	BTU/hrft²°F
Reboiler	1140	200
Steam / Liquid	850	150
Condenser	850	150
Liquid / Liquid	230 - 455	40 - 80
Steam / Gas	15	2.5
Liquid / Gas	10 - 60	2 - 11
Gas / Gas	6 - 30	1 - 5

-> High heat transfer coefficient = High heat transfer per unit area and per degree temperature difference

-> Low heat transfer coefficient = Low heat transfer per unit area and per degree temperature difference

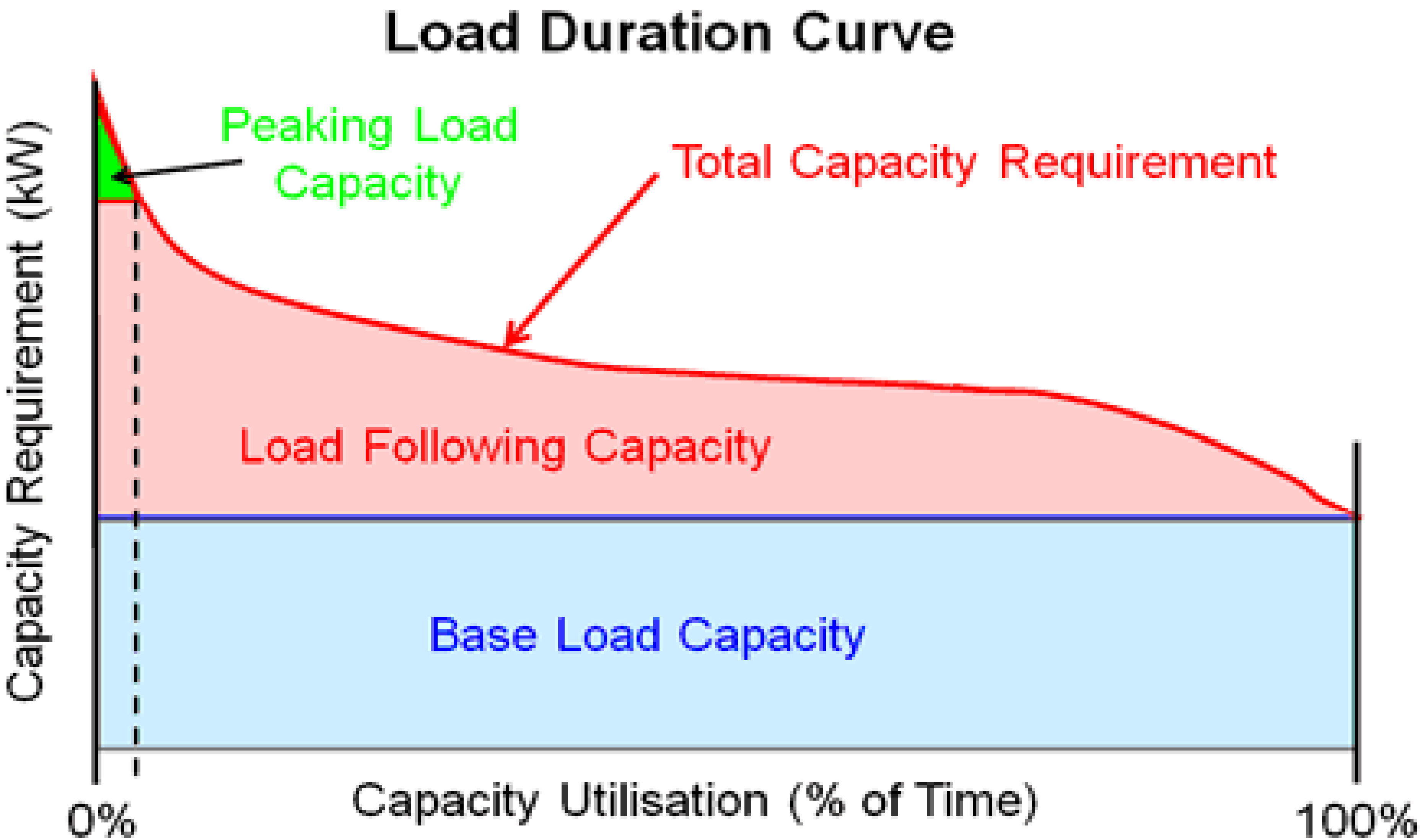
Ranges of heat transfer coefficients

These are only examples.

According to the surface arrangement you can find several cases in the literature.

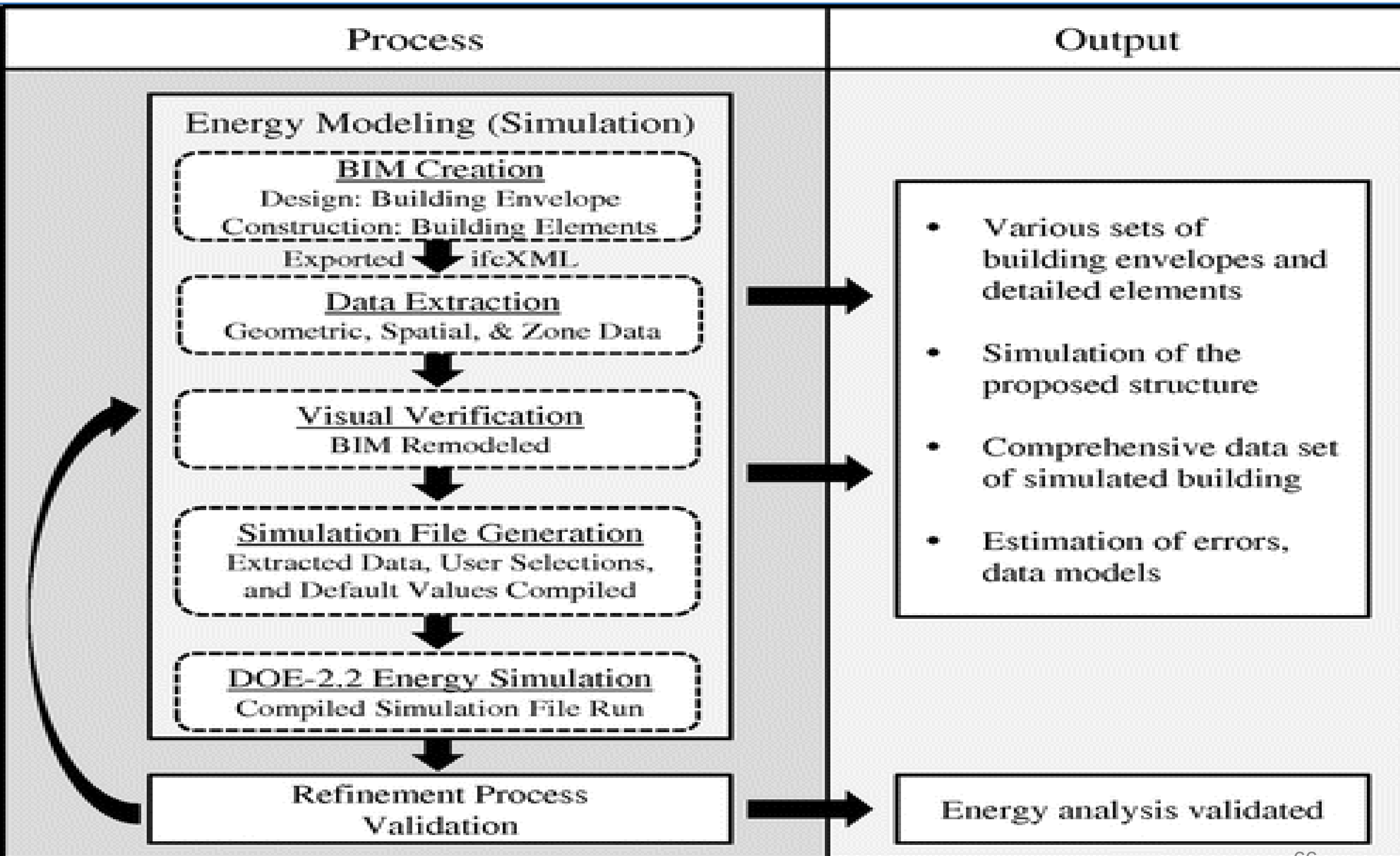
Heat transfer coefficient has different value range at different types of fluid:

- In case of: water boiling: $5000 < \alpha < 20000$ W/m^{2}K
- In case of water flow: $500 < \alpha < 2000$ W/m^{2}K
- In case of steam flow: $100 < \alpha < 1000$ W/m^{2}K
- In case of air or flue gas: $10 < \alpha < 200$ W/m^{2}K

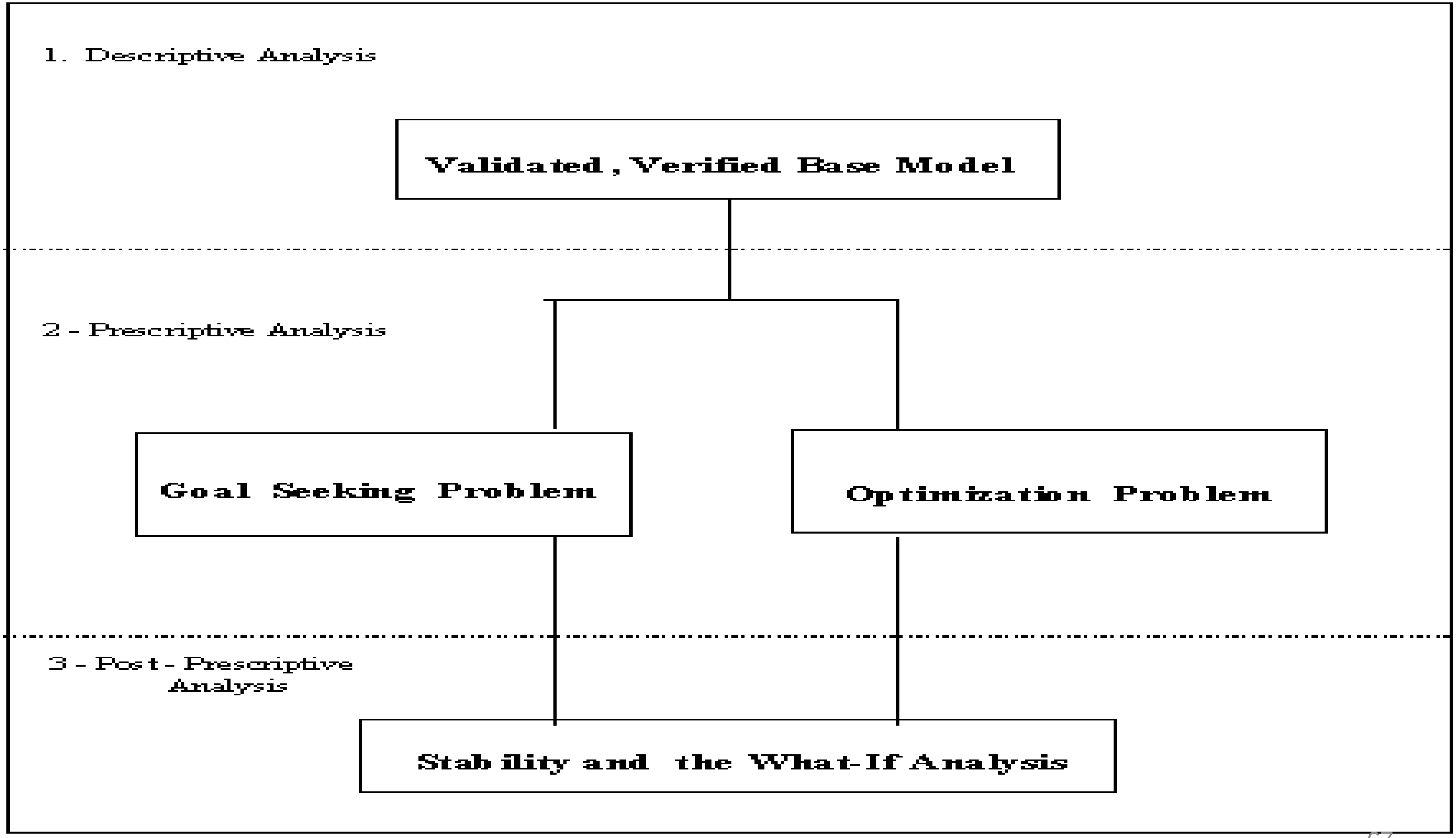

Load Duration Curve
Peaking Load
Capacity
Total Capacity Requirement
Load Following Capacity
Base Load Capacity
Capacity Requirement (kW)
Capacity Utilisation (% of Time)
0%
100%

Load characteristics

- The accuracy of analytical results depends on modeling of power system components, devices, and controls.
- Power system components - Generators, excitation systems, over/under excitation limiters, static VAr systems, mechanically switched capacitors, under load tap changing transformers, and loads among others.
- Loads are most difficult to model.
  - Complex in behavior varying with time and location
  - Consist of a large number of continuous and discrete controls and protection systems
- Dynamics of loads, especially, induction motors at low voltage levels should be properly modeled.


Process
Output
Energy Modeling (Simulation)
BIM Creation
Design: Building Envelope
Construction: Building Elements
Exported
ifcXML
Data Extraction
Geometric, Spatial, & Zone Data
Visual Verification
BIM Remodeled
Simulation File Generation
Extracted Data, User Selections, and Default Values Compiled
DOE-2.2 Energy Simulation
Compiled Simulation File Run
Refinement Process
Validation
• Various sets of building envelopes and detailed elements
• Simulation of the proposed structure
• Comprehensive data set of simulated building
• Estimation of errors, data models
Energy analysis validated

A Development Process for Systems Simulation



Sl No.	Equipment/ Reason	Expected Savings per annum (kWh/KVAh)	Expected Savings per annum (Rs.)	Expected Capital Cost (Rs.)	Payback Period	Action Required
F. Illumination:						
1.	Use of energy efficient lights	3,65,000 kWh	Rs. 12,77,500/-	Rs. 6,00,000/-	6 months	Replacing of existing HPMV lamps with HPSV lamps.
2.	Use of 28 W tube Lights	1,13,000 kWh	Rs. 4,00,000/-	Rs- 8,00,000/-	24 months	Replacing of existing 1000 tube lights with 28 W T/L having electronic chokes.
Total		**35,40,150 kWh & 149 KL Oil**	**Rs. 1,55,70,074/-***	**Rs.51,70,000/-**		

	Belgium			European Union		
	1990	2000	2008	1990	2000	2008
CO_2 Emission/capita (tCO_2/capita)	10.37	11.01	9.19	8.52	7.84	7.65
CO_2 Emission of transport/capita (tCO_2/capita)	2.00	2.36	2.32	1.59	1.83	1.91
CO_2 Emission of residential sector per household (tCO_2/household)	4.63	4.73	3.53	2.94	2.51	2.22
Average electricity consumption per capita (kWh/capita)	4636	5608	4783	1283	1480	1634

Source: Eurostat.

RESULTS OF THE AUDIT

Annual consumption of the academic building
10,446 Units
Cost ₹1,61,180

- Proposed Consumption
  9,691 Units
- Cost
  ₹1,49,306
- Energy Saving
  755 Units (7.22%)

(Results calculated annually)

Cost Saving
₹11,874 (7.3%)

TECHNOLOGY USED

- The students used Integrated Energy Solutions (IES)
- IES helps to assess the performance of buildings and its facilities remotely and suggests improvements to make them energy efficient
- IES gauges the energy use through the availability of natural light as against the use of powered light
- The results help make decisions about prioritizing measures to improve the energy efficiency of a building and reduce costs
- The methodology and the tool can be used during the planning stage of a building or after a structure is constructed

Energy conservation Opportunities

- One of the primary ways to improve energy conservation is to use an energy audit.
- An **energy audit** is an inspection and analysis of energy use and flows for energy conservation in a building, process or system to reduce the amount of energy input into the system without negatively affecting the output.
- This is normally accomplished by **trained professionals** and can be part of some of the national programs discussed above.
- In addition, recent development of **smar tphone apps** enable homeowners to complete relatively sophisticated energy audits themselves

ENERGY CONSERVATION OPPORTUNITIES

- Compare the actual values with the design / performance test values if any deviation is found, list the factors with the details and suggestions to over come.
- Compare the specific energy consumption with the best achievable value (considering the different alternatives). Investigations to be carried out for problematic areas..
- Enlist scope of improvement with extensive physical checks / observations. Based on the actual operating parameters, enlist recommendations for action to be taken for improvement, if applicable such as:

✓ Replacement of pumps

✓ Impeller replacement

✓ Impeller trimming

✓ Variable speed drive application, etc

Energy conservation refers to the concept of reducing energy consumption through using less of an energy service

- ✓ Most of the energy we use cannot be re used.
- ✓ Energy consumption is important when it comes to climate change.
- ✓ It is needed to reduce adverse effect of pollution due to excessive use of fossil fuels.
- ✓ Increasing energy demand is a drain to national economy

ENERGY AUDIT REPORT

1. ACKNOWLEDGEMENT
2. CONTENTS
3. EXECUTIVE SUMMARY
4. SUMMARY OF SAVINGS
5. INTRODUCTION
6. PLANT ENERGY SYSTEM
7. ENERGY USAGE PATTERN
8. ENERGY INDICATORS
9. ENERGY SAVING OPTIONS/RECOMMENDATIONS
10. ANNEXURE/PLANT BASE LINE DATA

- Filed observation and savings calculations.
- List of suppliers .
- Action plan for ENCON implementation

Energy Audit Report

Executive Summary	Objectives, scope, type or audit and summary of energy saving recommendations
Management Of Energy	➢Policy and targets ➢Energy data, documentation and monitoring ➢Compliance towards the regulations ➢Energy management team ➢Energy audit team
Plant/Building Production/se rvices Description	➢Brief description for production process-manufacturing/services-buildings ➢Process flow diagram and major components of operation

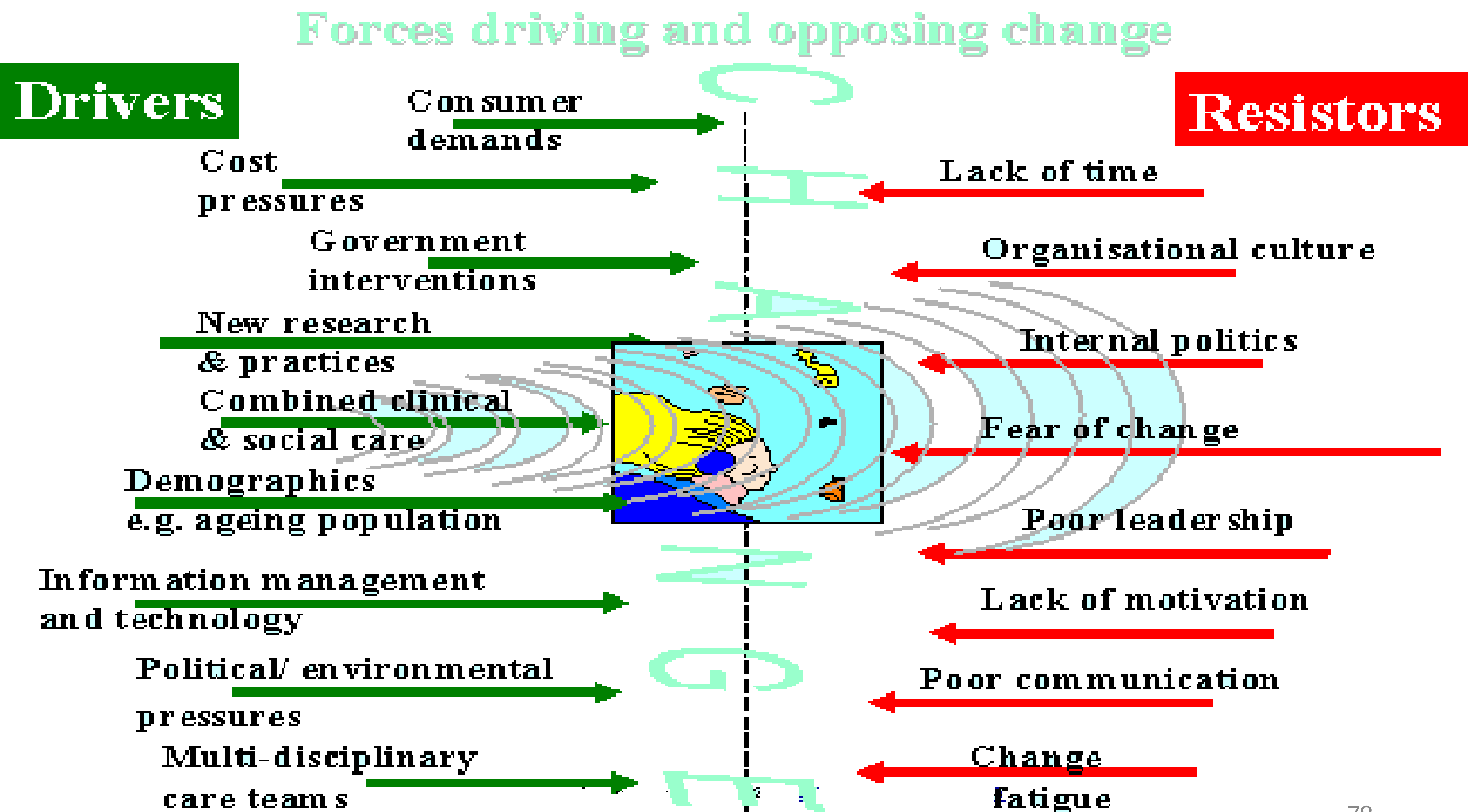
Energy Audit Reporting

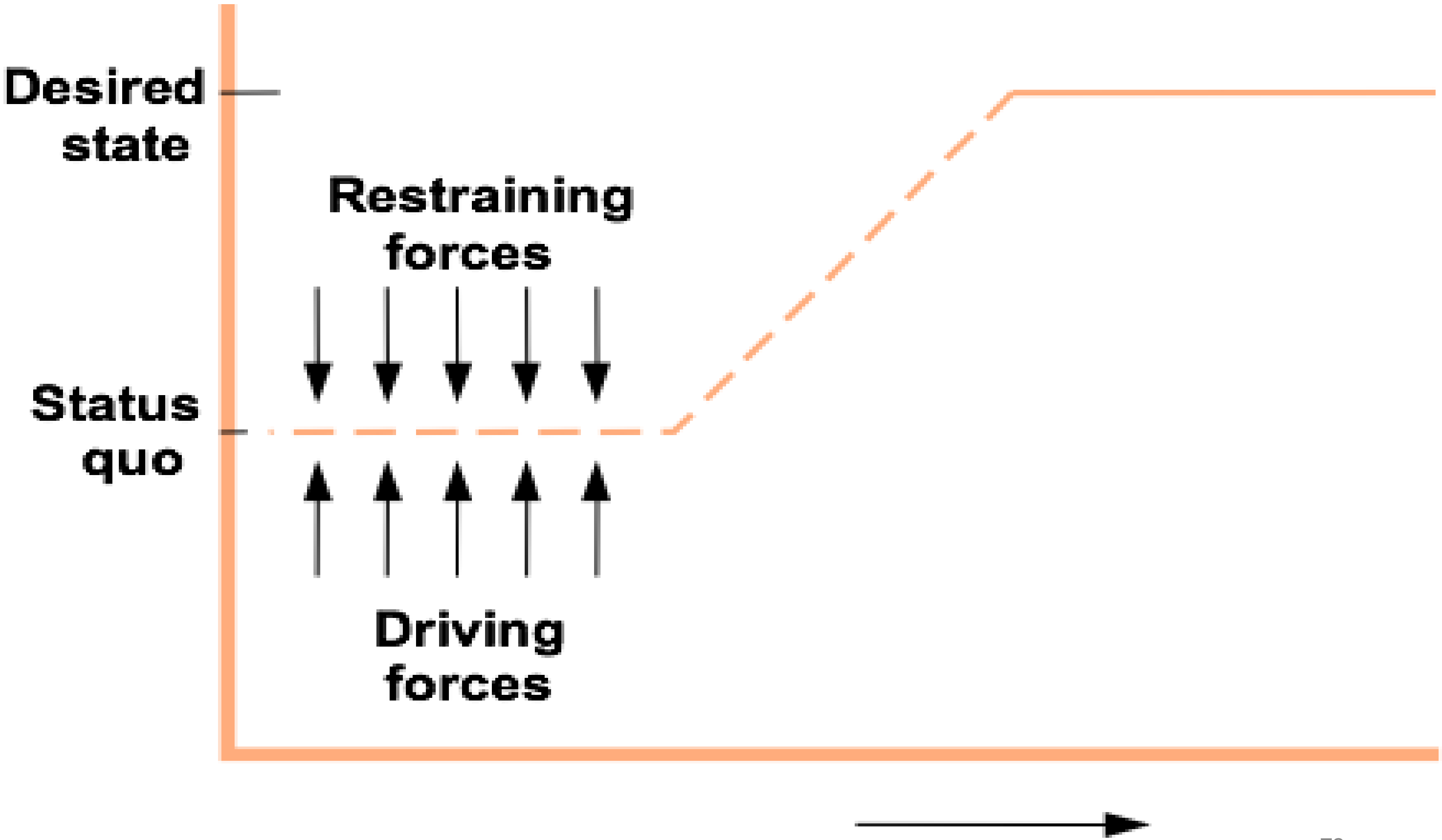
- Energy audit report should be based on actual historical and field collected data and any recommendations should be supported by reliable engineering calculations.
- The report should consists of several sections namely,
  - ✓ **Executives summary** – Highlight major findings
  - ✓ **Introduction** – Project background, scope, assumptions and limitations
  - ✓ **Energy Audit Methodology** - Energy Audit Process and Energy Audit Measurement Equipment.
  - ✓ **Building profile**
    - ✓ **Site description** – Audited site and description
    - ✓ **Historical energy consumption** – Energy consumption trend, EEI, specific consumption
    - ✓ **Load profile and apportioning** – Energy distribution
    - ✓ **Production energy intensity indices** (kWh/m^2/year or tonne /kWh) – EEI improvement
  - ✓ **Energy saving measures and recommendation** - Type of Energy Saving Measures, estimated saving in kWh and RM, assumptions, the implementation costs, Simple Payback Periods and some remarks on the recommend measures.
  - ✓ **Summary of Implementation Strategies** - Summary of the proposed energy savings and estimated investment cost.
  - ✓ **The Way Forward** - Describe proposed energy conservation policy for maintenance retrofitting and design in achieving green building and sustainable development.
  - ✓ **References and appendices**.

UNIT III

ENERGY POLICY PLANNING AND IMPLEMENTATION

Force-Field Analysis



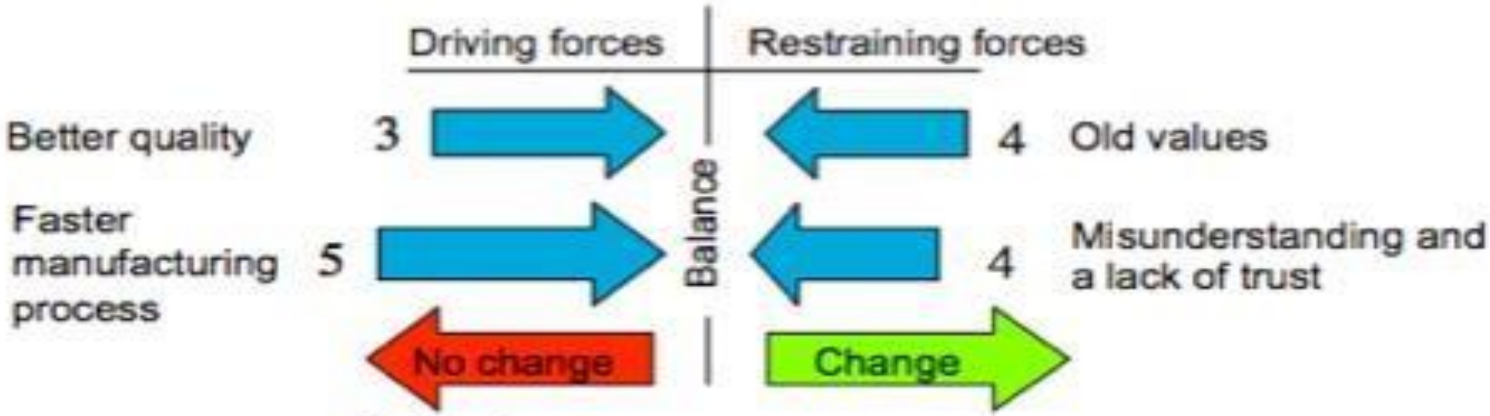

Desired state
Restraining forces
Status quo
Driving forces

Force Field Model

Visualize the power balance and the strong forces in the form of feelings, values, power and politics that are restraining change.

1. An automatisation of the production process, due to uneven quality and long lead times

2. The increased competition will otherwise put us out of business



Action plan

1, Involve all the personal in the design of the new process and educate them in the new system

ENERGY POLICY IN INDIA

- The Ministry of power has been designated as the nodal agency for energy conservation

Major Government initiatives towards energy conservation

- Depreciation allowance at 100% in the first year on certain energy saving devices and systems

- Reduced custom duty is applicable on specified equipment/devices used in the industry

NATIONAL STEEL AND AGRO INDUSTRIES LTD.,
SEJWAYA.

ENERGY MANAGEMENT POLICY

We at NSAIL Sejwaya are committed to continually improve overall energy performance.

We shall achieve this by:

1. Enhance Energy conservation awareness and encourage participation of stake holders in all related activities.
2. Continually monitor and improve manufacturing process to reduce and control energy consumption
3. Comply with all Relevant legal and other requirements related to energy use, consumption and efficiency.
4. Set and Review Objectives targets for continual improvements, related to energy performance.
5. Ensure the availability of information and resources to achieve planned targets.
6. Procure energy efficient Equipments and services through latest available technologies and design.
7. Promote renewable energy and green initiatives to conserve natural resources

" We are committed to conserve the precious energy in and out of our organisation."

Place : Sejwaya

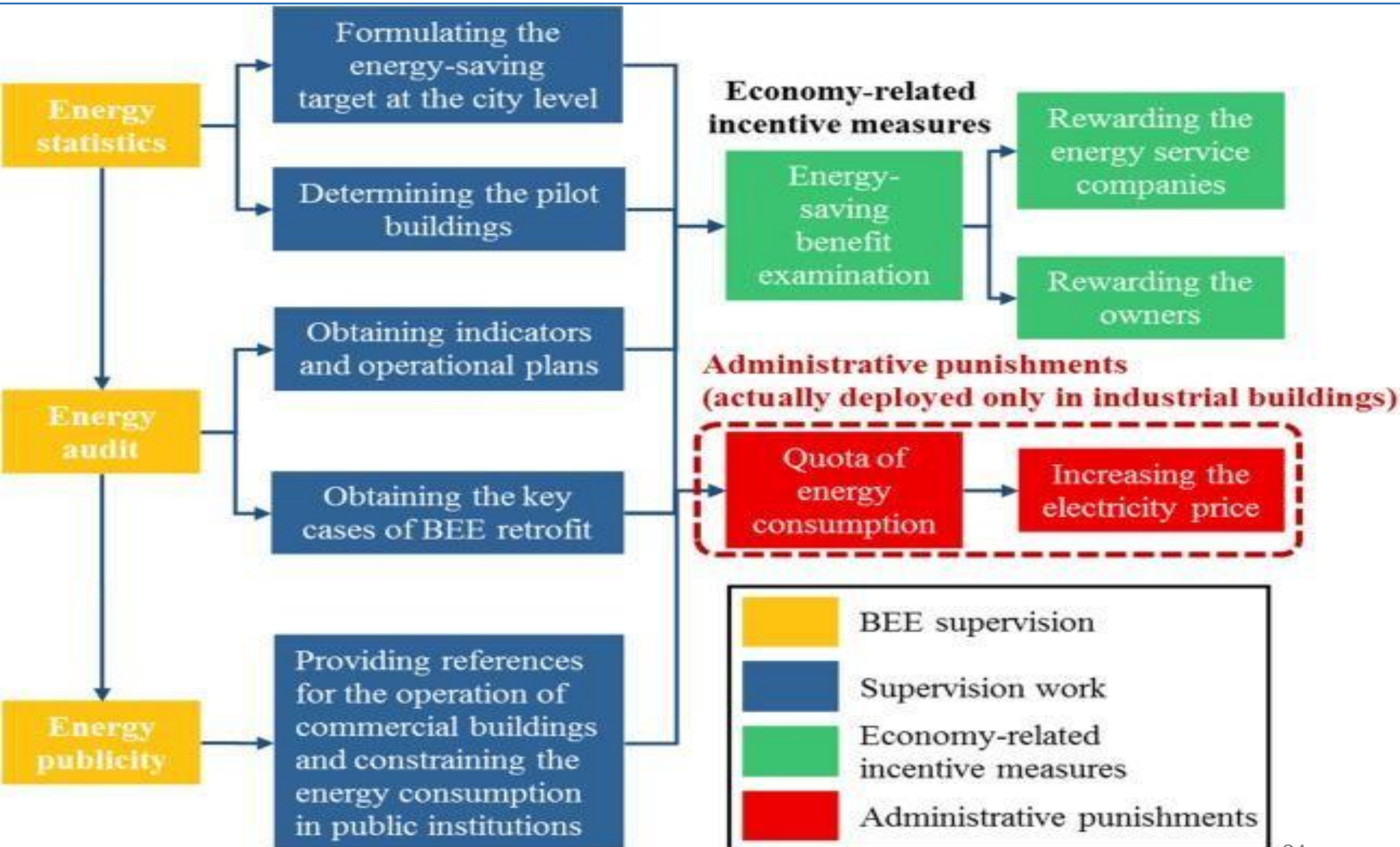
Date : 06th April, 2016

(Nagalingam Goli)

Managing Director

Prospective of energy audit

- Energy manager sees equipment as consumers of energy.
- The sales person ,keen to show latest technology.
- The production manager - reliability and performance of the plant.
- The maintenance engineer – the costs of maintaining plant and related on going problems.



Energy statistics
Energy audit
Energy publicity
Formulating the energy-saving target at the city level
Determining the pilot buildings
Obtaining indicators and operational plans
Obtaining the key cases of BEE retrofit
Providing references for the operation of commercial buildings and constraining the energy consumption in public institutions
Economy-related incentive measures
Energy-saving benefit examination
Rewarding the energy service companies
Rewarding the owners
Administrative punishments (actually deployed only in industrial buildings)
Quota of energy consumption
Increasing the electricity price
BEE supervision
Supervision work
Economy-related incentive measures
Administrative punishments

- **Location of Energy Manager**
- The energy management function, whether vested in one "energy manager or coordinator" or distributed among a number of middle managers, usually resides somewhere in the organization between senior management and those who control the end-use of energy. Exactly how and where that function is placed is a decision that needs to be made in view of the existing organizational structure.

Top Management Commitment and Support

- Commitment is to allocate manpower and funds to achieve continuous improvement.
- To establish the energy management programme, leading organizations **appoint energy manager, form a dedicated energy team and institute an energy policy.**

❑ **Appoint an Energy Manager**

- ➢ setting goals
- ➢ tracking progress
- ➢ promoting the energy management program.

An Energy Manager helps an organization achieve its goals by establishing energy performance as a core value.

1.Top Management Commitment and Support

❑ **Form A Dedicated Energy Team**

- The tasks of energy team are executing energy management activities across different parts of the organization and ensuring integration of best practices.

❑ **Institute an Energy Policy**

- Energy policy provides the foundation for setting performance goals and integrating energy management into an organization's culture and operations.

Top Management Commitment and Support

❑ **Responsibilities and Duties of Energy Manager**

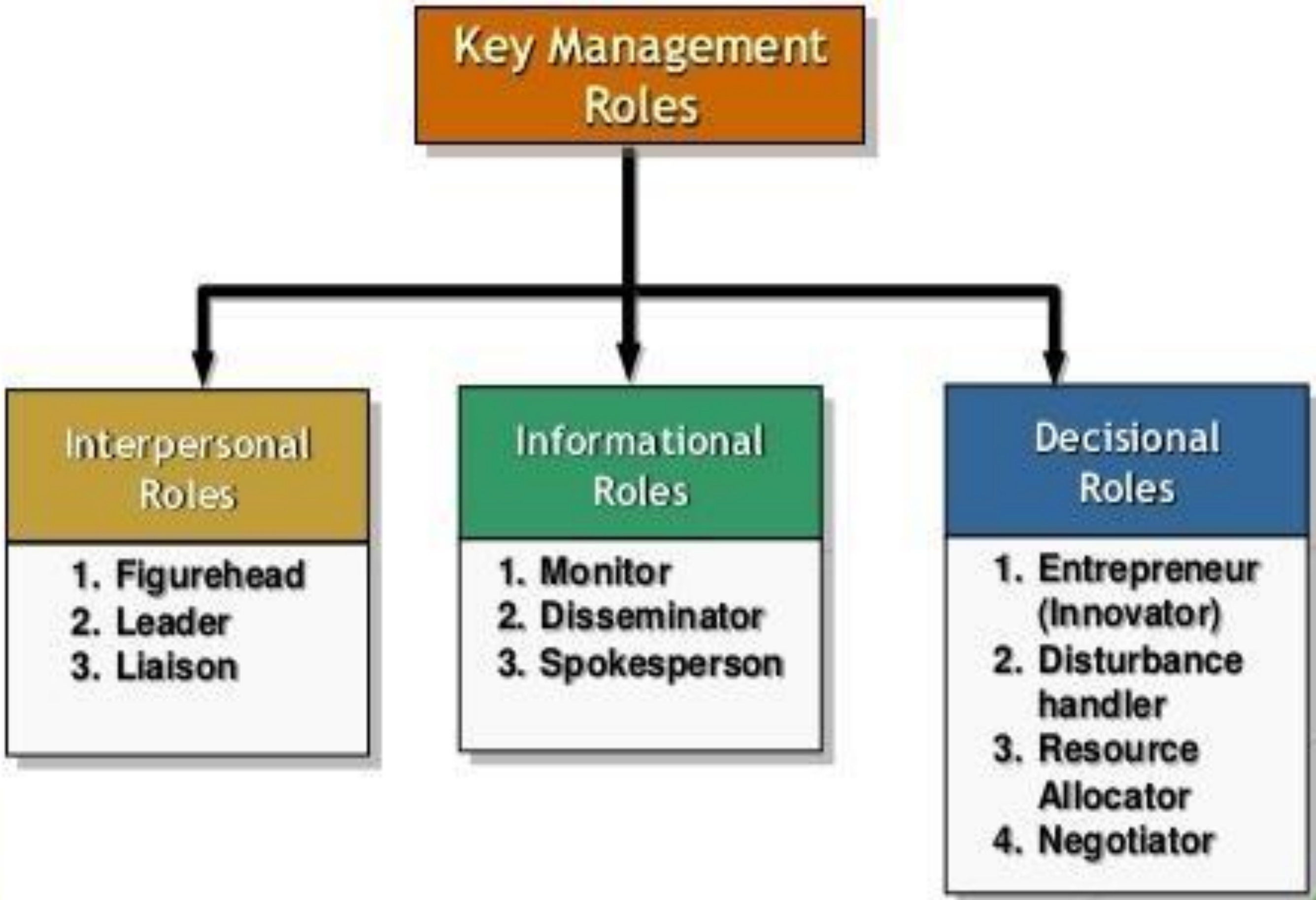
- **Initiate activities** to improve monitoring and process control to reduce energy costs.
- **Analyze equipment performance with respect to energy efficiency**
- **Ensure proper functioning and calibration of instrumentation** required to assess level of energy consumption directly or indirectly.
- **Prepare information material and conduct internal workshops** about the topic for other staff.

Top Management Commitment and Support

❑ Duties of Energy Manager

- **Report to BEE and State level Designated Agency** once a year the information with regard to the energy consumed and action taken on the recommendation
- **Provide support to Accredited Energy Audit Firm**
- **Provide information to BEE as demanded in the Act**
- **Prepare a scheme for efficient use of energy and its conservation and implement the scheme**

Key Managerial Roles



- **Responsibilities and Duties of Energy Manager are highlighted below:**
- Establish an energy conservation cell & prepare an annual activity plan
- Develop and manage training programme for energy efficiency at operating levels
- Develop integrated system of energy efficiency and environmental improvement
- Initiate activities to improve monitoring and process control to reduce energy costs
- Co-ordinate implementation of energy audit/efficiency improvement projects through external agencies
- Establish / participate in information exchange with other energy managers of the same sector through association

Energy Manager

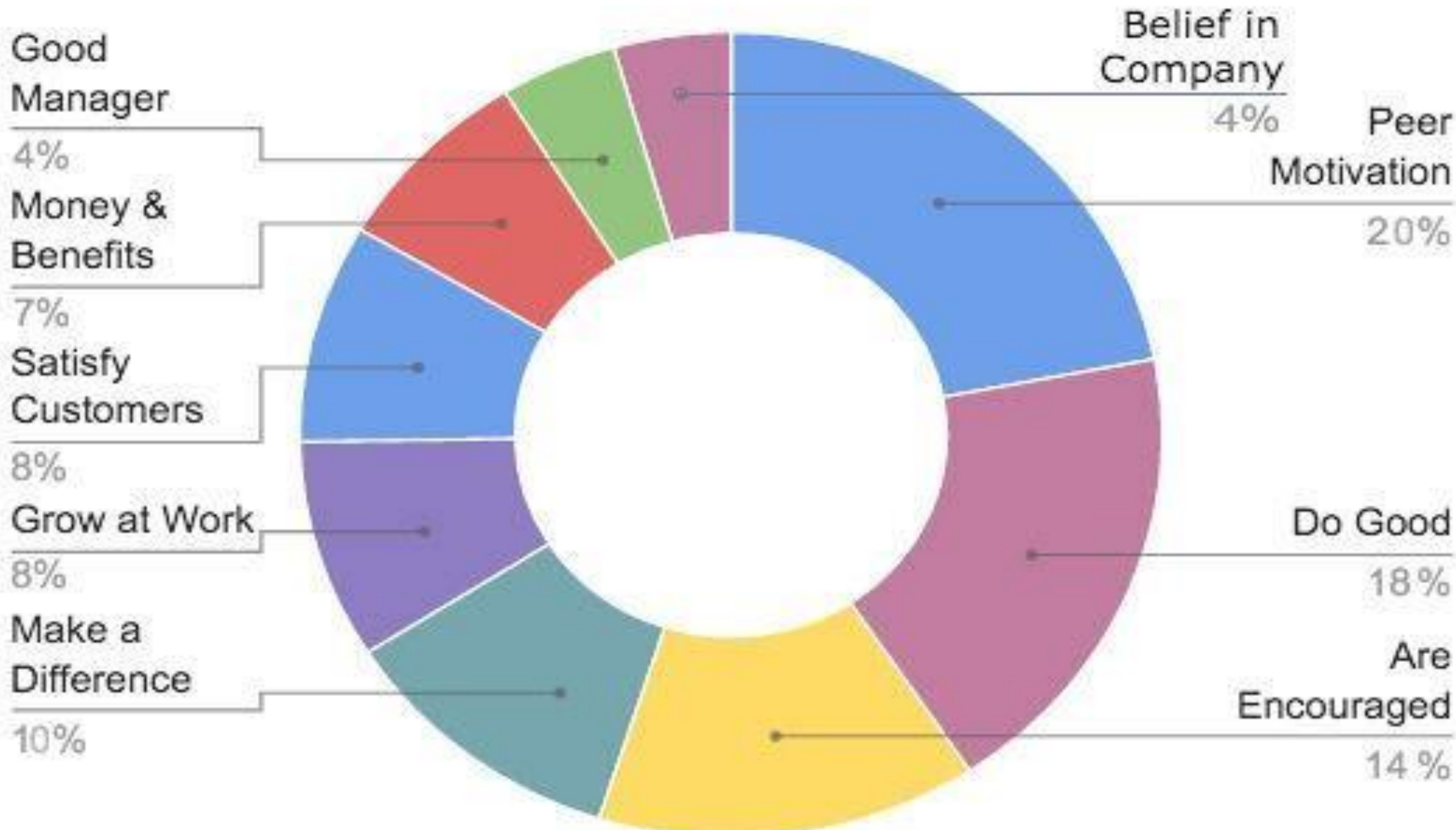
Role:
Coordinate all aspects of energy management, from reduction of carbon dioxide emissions, to waste management and sustainable development by:

- encouraging the use of renewable/sustainable energy resources within an organization or community;
- developing solutions for carbon management;
- raising the profile of energy conservation.

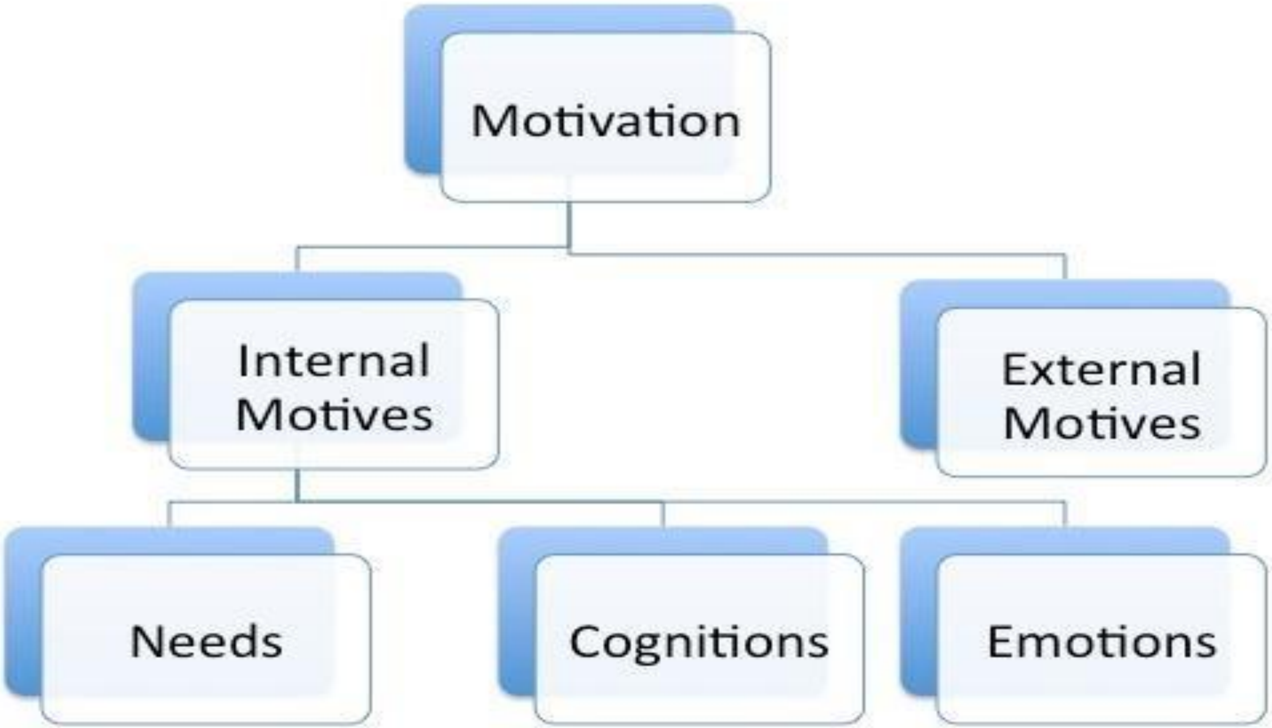
Responsibilities:

- Your duties will vary depending on the setting you're working in, but in general you'll be:
- developing, coordinating, and implementing strategies and policies to reduce energy consumption;
- Creating policies and systems for buying energy and helping with contract negotiations;
- Providing technical and practical advice and offering training on energy efficiency;
- Developing promotional activities and materials; promote particular schemes;
- Liaising and negotiating with contractors, the building supplies industry, council services and other relevant organizations;
- Keeping accurate records and regularly collecting energy monitoring data;
- Carrying out site inspections and energy surveys;
- Benchmarking energy consumptions against best practice guidelines;
- Keeping up to date with legislation.


Flexibility: work/life
Pay and Benefits
Working Conditions
Employee Motivation
Career Advancement
Job Security
Work Itself


Belief in Company
4%
Peer Motivation
20%
Do Good
18%
Are Encouraged
14%
Good Manager
4%
Money & Benefits
7%
Satisfy Customers
8%
Grow at Work
8%
Make a Difference
10%

Hierarchy of the Four Sources of Motivation



Five Finger Story


MARKETING
PLAN
advertising
research
finance
brand
sales
distribution
performance
strategy
clients
budget
action
training
share
responsibilities
results
incentives
promotion
development
cost
target
prices
benchmarks
analysis
profit
timescale
expense
channel
requirements
management
summary
opportunities

Communications Plan

Audience	Sub Audience	Training Method	Frequency
Finance	Managers	1:1 training	One time
		In-context training	Ongoing
	End Users	In-context training	Ongoing
Sales	Account Managers	Custom Video	Ongoing
		Classroom training	One time
	Account Team	Quick start guides	Ongoing
		Webinar	Offered weekly for four weeks

Communications Plan

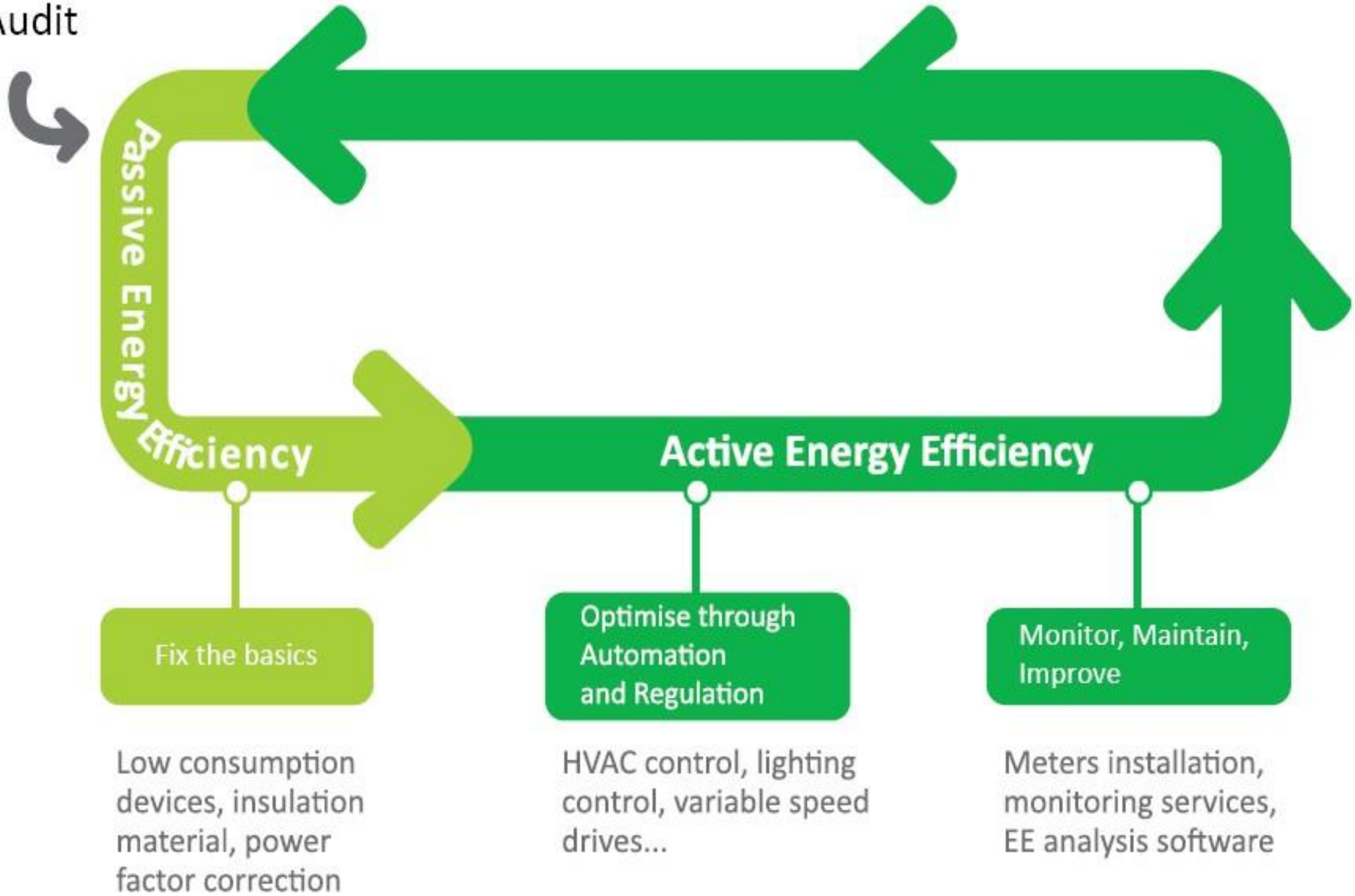
Audience	Sub Audience	Channel	Frequency	Purpose	Content Developer	Sender
Finance	Managers	Status call and email recap	Weekly	Discuss key accomplishments, upcoming milestones, issues / risks, and action items.	John Doe	Jane Doe
		CFO Update	Monthly	Provide credibility to the project and create awareness and shared understanding through updates.	John Doe	Jane Doe
		Leadership Monthly Calls	Monthly	Continually evangelize work and highlight project "wins".	John Doe	Jane Doe
	End Users	Web Portal	Weekly Updates	Update on project efforts with links to supporting detail.	John Doe	Jane Doe
Sales	Account Managers	Status call And email recap	Weekly	Discuss key accomplishments, upcoming milestones, issues / risks, and action items.	John Doe	Jane Doe
		Account segmentation and pipeline meeting	Weekly	Provide visibility into the business impact of the project. Ask questions as necessary.	John Doe	Jane Doe
	Account Team	Weekly Account Wins Newsletter	Will submit content on a bi-weekly basis	The role-targeted newsletter will aggregate many messages currently sent through email and other newsletters	John Doe	Jane Doe
		Web Portal	Weekly Updates	Update on project efforts with links to supporting detail.	John Doe	Jane Doe

UNIT IV
ENERGY BALANCE AND MIS

ENERGY EFFICIENCY

- **First law efficiency: amount of energy without any consideration of the quality or availability of energy**
  - Ratio of the amount of energy delivered where it is needed to the amount of energy actually supplied to meet that need
- **Second law efficiency: how well matched the energy use is with the quality of the energy source**
  - Important to the study of energy use because it shows where improvements can be made to increase the efficiency of an energy system
  - Example: Not using a blowtorch to light a match

Energy Audit Model



4 Steps for Reducing Facility Energy Costs

- **Request submetering from the utility provider.**

  Get energy usage data as granular as possible with multiple submeters.

- **Use vendor resources to enter consumption data.**

  Many vendors offer ways to streamline the process of entering utility-bill data into the system for analysis.

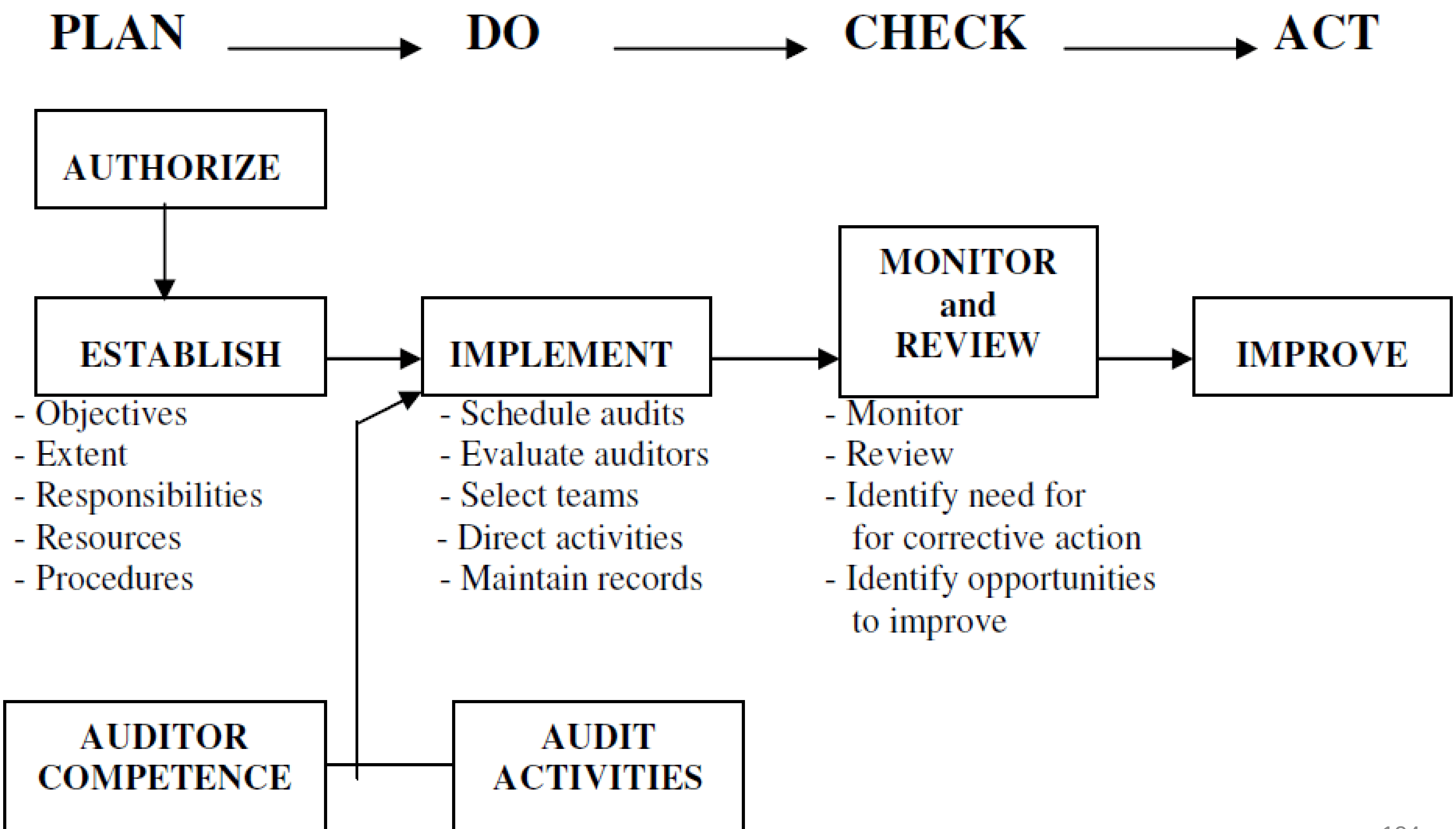
- **Integrate Energy Star ratings to see benchmarks.**

  Use Energy Star ratings to see how well your energy management initiatives are working.

- **Identify specific areas for improvement and implement energy-saving initiatives.**

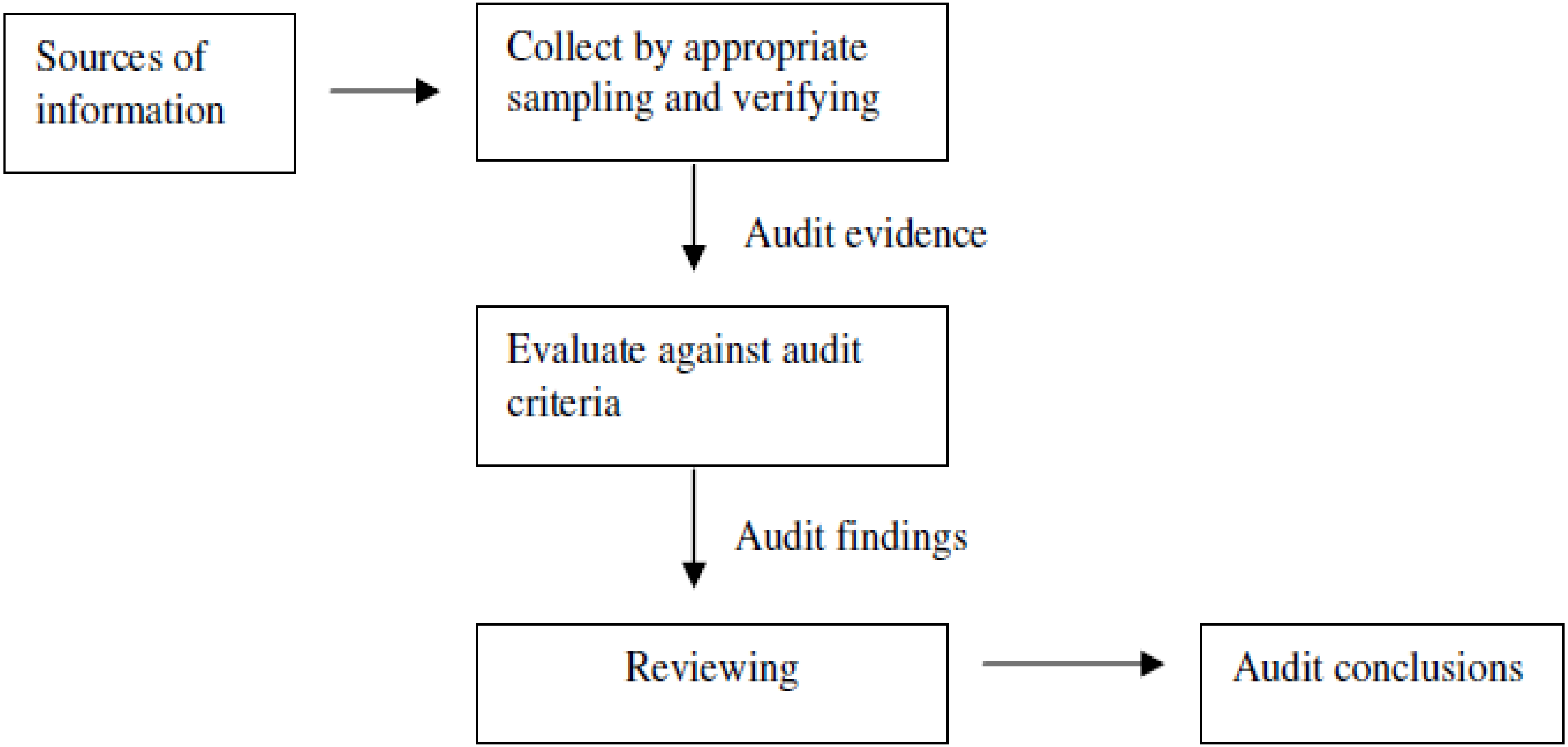
  Once data is in the system, use reporting tools to see which assets use the most energy. Repair or replace these assets, or change power schedules to reduce energy costs. And get other occupants involved through an energy-reduction program or contest.

Managing an Audit Program – Process Flow



Collecting and verifying information

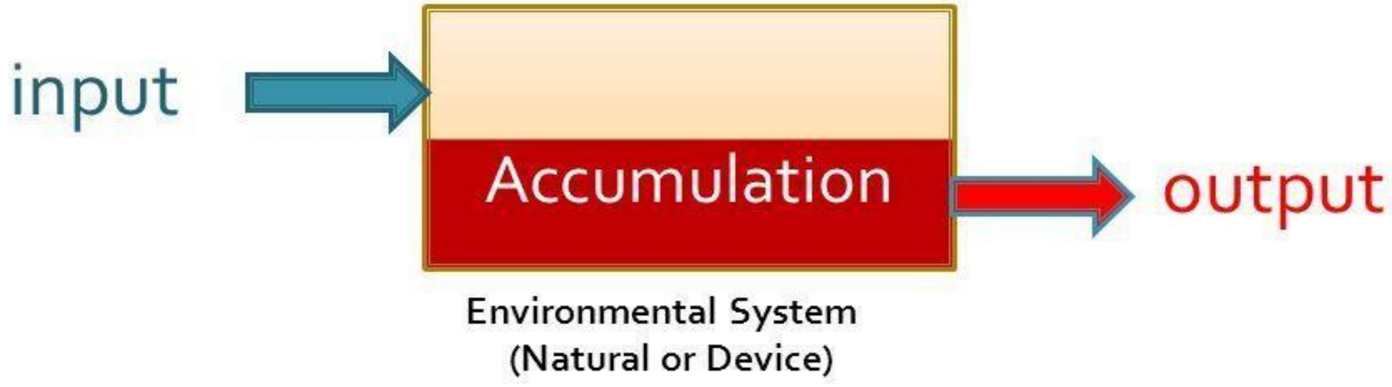
Process for collecting information to reaching audit conclusions

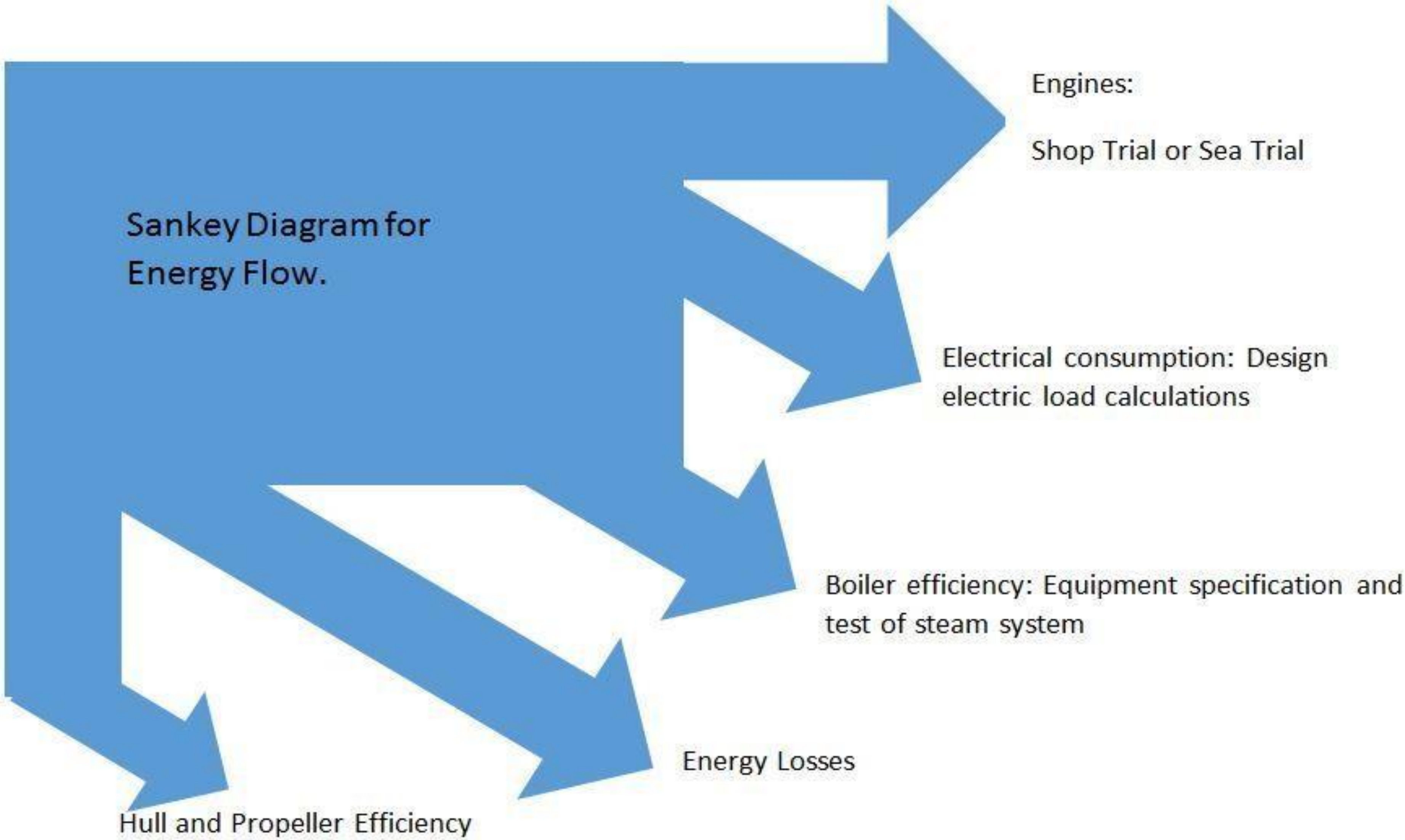


Material Balances

- The simplest form of a materials balance or mass balance

Accumulation = input – output




Sankey Diagram for Energy Flow.
Engines:
Shop Trial or Sea Trial
Electrical consumption: Design electric load calculations
Boiler efficiency: Equipment specification and test of steam system
Energy Losses
Hull and Propeller Efficiency

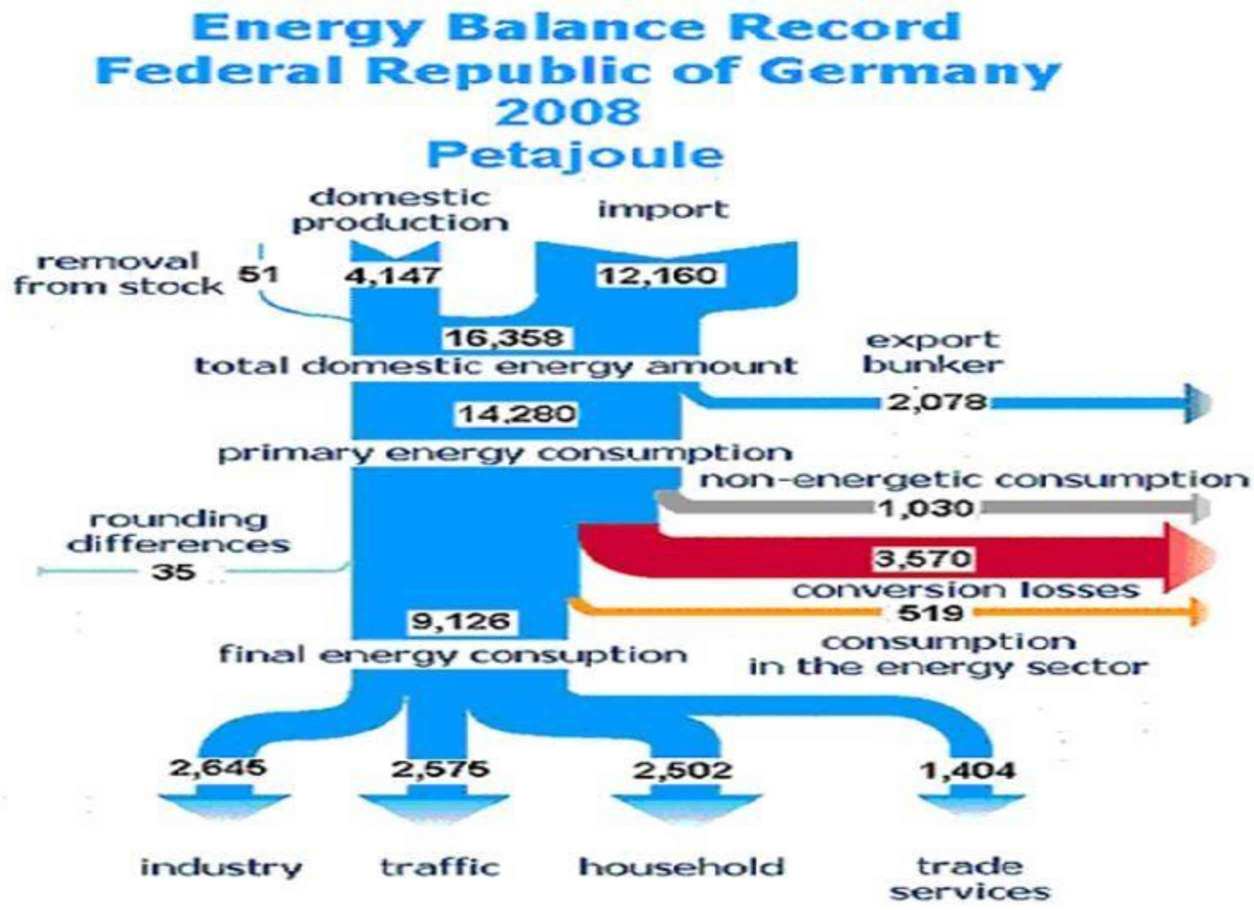
TÉCNICO LISBOA

Energy loss

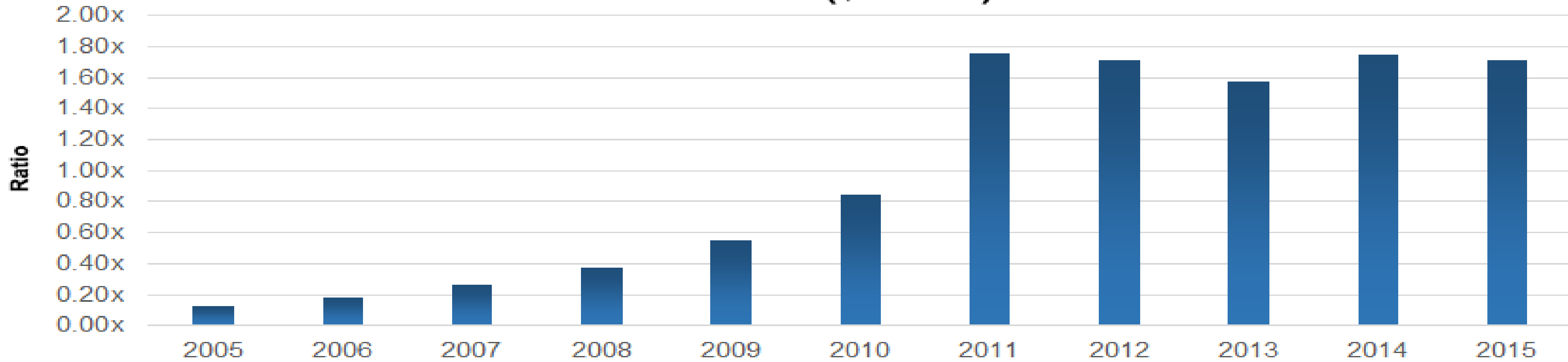
Overall energy losses in a plant can result from losses due to designs that do not incorporate energy efficient specifications such as:

- heat recovery option
- operations that run on inefficient methods
- poor or non-energy efficiency-conscious maintenance programme

Reducing these losses will substantially increase the plant's efficiency, but **we need data** to identify and quantify the losses and subsequently suggest suitable techno-economic solutions to minimize the losses. **This data can be acquired through energy audits.**


Energy Balance Record
Federal Republic of Germany
2008
Petajoule
domestic production
import
removal from stock
51
4,147
12,160
16,358
total domestic energy amount
export bunker
2,078
14,280
primary energy consumption
non-energetic consumption
1,030
rounding differences
35
3,570
conversion losses
519
9,126
final energy consuption
consumption in the energy sector
2,645
2,575
2,502
1,404
industry
traffic
household
trade services

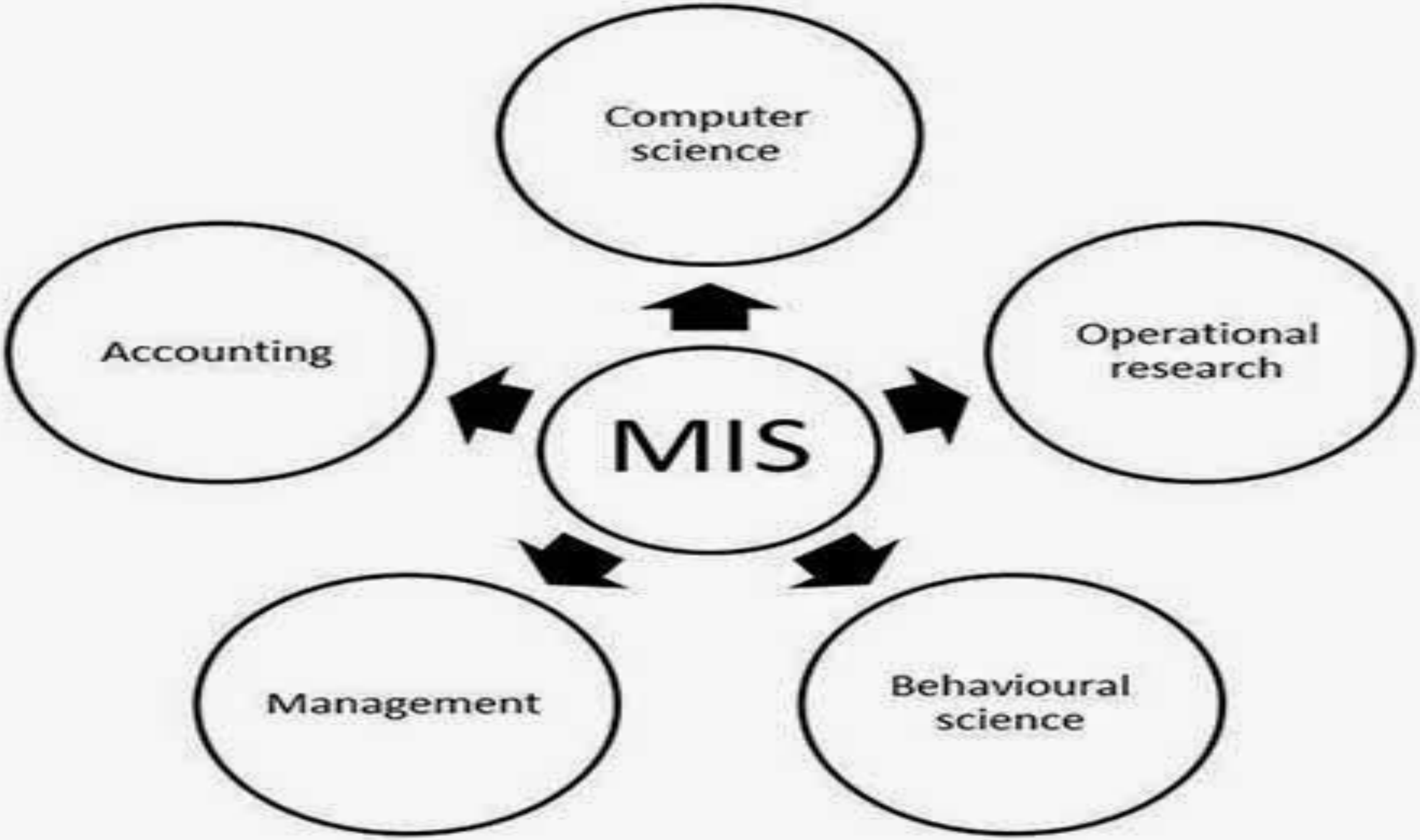
Annual Chesapeake Energy Ratio of Off-Balance Sheet to On-Balance Sheet Debt 2005 - 2015 ($US Mil)

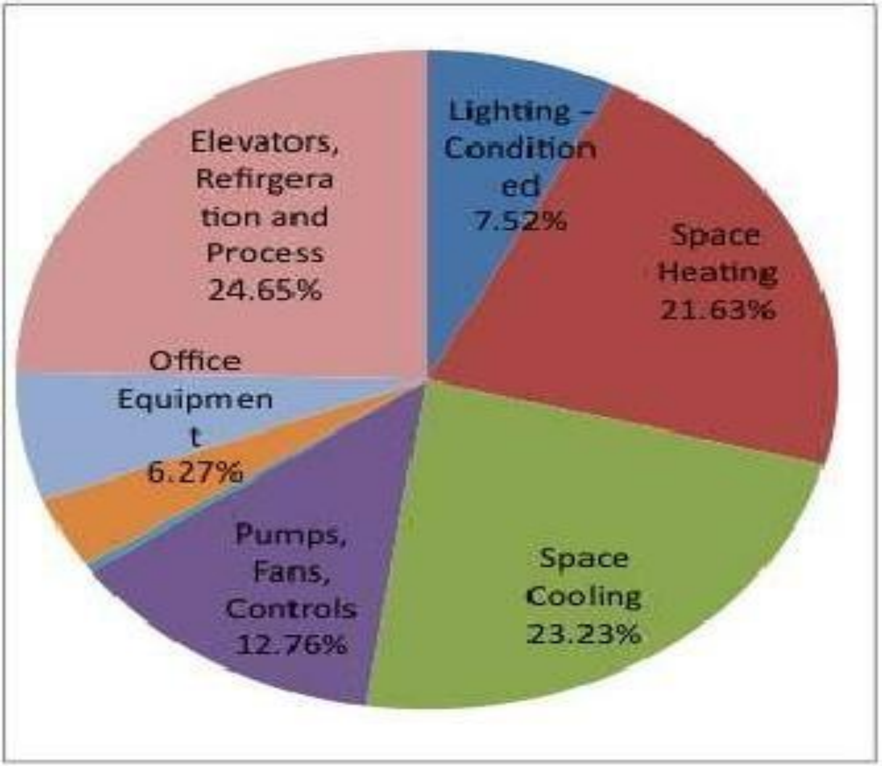


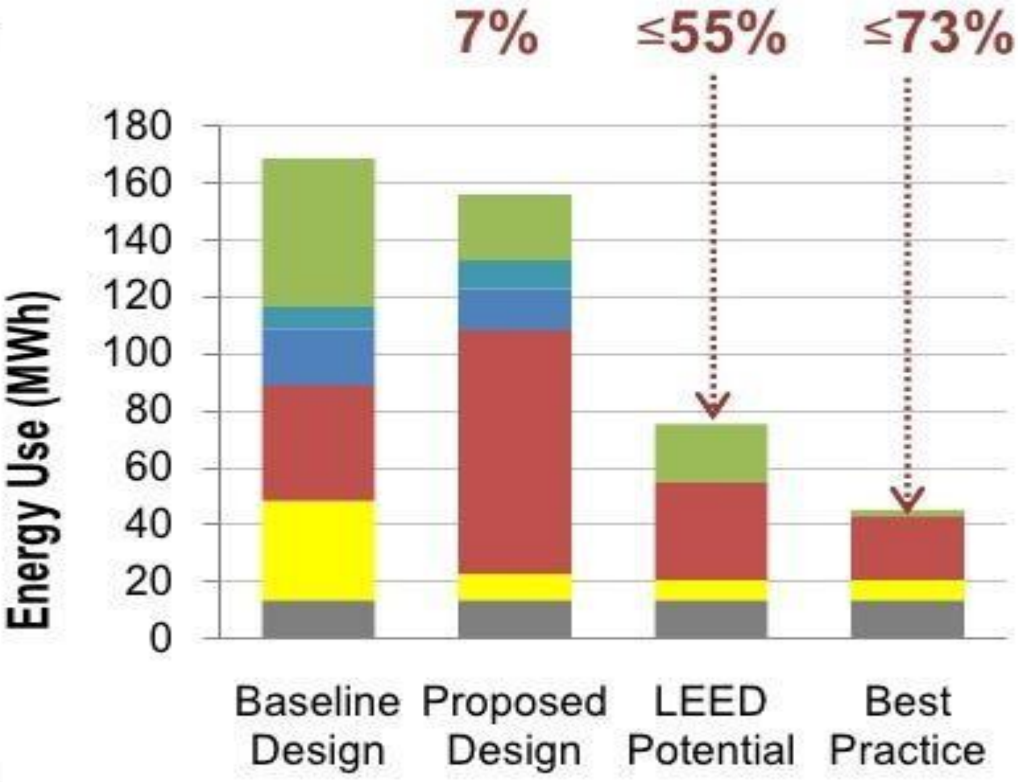
Off-Balance Sheet Debt							On-Balance Sheet Debt				TOTAL
Year	G,P, T[1]	Drilling Contracts	Other	Operating Leases[2]	VPPs[3]	Total	ST Debt	LT Debt	Minority Int	Total Debt	Combined Total Debt
2005	113	323	227	14	-	677	-	5,490	-	5,490	6,167
2006	382	396	290	282	-	1,350	-	7,376	-	7,376	8,726
2007	535	212	182	857	1,100	2,886	-	10,950	-	10,950	13,836
2008	1,566	276	507	946	1,622	4,917	-	13,175	-	13,175	18,092
2009	2,780	181	121	882	3,292	7,256	-	12,295	897	13,192	20,448
2010	4,424	249	381	916	4,769	10,739	-	12,640	-	12,640	23,379
2011	13,773	407	261	998	5,622	21,061	-	10,626	1,337	11,963	33,024
2012	18,490	202	118	768	6,031	25,609	463	12,157	2,327	14,947	40,556
2013	17,190	41	30	375	6,031	23,667	-	12,886	2,145	15,031	38,698
2014	16,043	502	466	11	5,481	22,503	381	11,154	1,302	12,837	35,340
2015	13,965	280	186	9	4,331	18,771	381	10,354	259	10,994	29,765

[1] Gathering, processing, and transportation
[2] Includes rigs, compressors, and other
[3] Stated amount received of all VPPs. CHK's actual obligation was likely less each year, depending on the remaining term of each individual contract.

Source: Company documents, NGI calculations


Computer science
Accounting
Operational research
MIS
Management
Behavioural science





Energy Modeling As We Know It

UNIT V

ENERGY AUDIT INSTRUMENTS

Energy Audit

Energy Audit Instruments

1. *Electrical parameters*
2. *Combustion analyzer*
3. *Fuel efficiency monitor*
4. *Fyrites- gas analyzer*
5. *Temperature measurements*
6. *Pressure measurements*
7. *Velocity measurements*
8. *Speed measurements*
9. *Leak detectors*
10. *Measurement of light*
11. *Measurement of water flow*
12. *Humidity measurement*

Energy Audit

Energy Audit Instruments

1. Electrical System Parameters

- These are instruments for measuring major electrical parameters such as ***kVA, kW, PF, Hertz, kVAr, Amps and Volts.***
- some of these instruments also measure harmonics. (Harmonic analyzer)
- These instruments are applied on-line i.e on running motors without any need to stop the motor.
- Instant measurements can be taken with hand-held meters, while more advanced ones facilitates cumulative readings with print outs at specified intervals.

Energy Audit Instruments

Some more Energy Audit Instruments

TEST INSTRUMENTS ACCURACY, CODE & CALIBRATION LAB

Accuracy of Energy Audit Instruments

• Pressure Measuring Instruments	0.1 % Acc.
• Temperatures	1/2 DIN Tolerance Or ASME CLASS 'A'
• Aux. Power Measuring Instruments	0.2 % Acc.
• Generator Power Measurement	0.1 % Acc.
• Flue Gas Analysis	0.5 % Acc.
• Data Logger	0.03 % Acc.
• Ultrasonic Flow Meter	0.5 % Acc.

Note: - Price and Quality / Grade of Energy Audit Depends largely on Instrument Accuracies

Advanced Force Gauge (AFG)

Key Features

- Excellent accuracy ±0.1% of full-scale
- N, kN, mN, gf, kgf, lbf and ozf measurement units
- RS232, digimatic and analogue
- Overload warning, with trend bar
- data acquisition software for additional test evaluation options

10 models, 2.5 N to 2500 N (0.55lbf to 550lbf)


EVERY ENDING
IS REALLY JUST A
NEW BEGINNING